SCIENCE ABSTRACTS.

Section A.—PHYSICS.

AUGUST 1919.

GENERAL PHYSICS.

974. *An Optical-lever Manometer.* **J. E. Shrader** and **H. M. Ryder.** (Phys. Rev. 13. pp. 321–325, May, 1919.)—To meet the demand for a gauge which will measure vapour pressures in the range between that which can be measured by the Knudsen gauge (0·001 mm.) and the ordinary mercury manometer, a new type of gauge has been devised. This consists of a rather large mercury manometer, in one arm of which a small optical lever is so adjusted that it measures small changes in level due to differences of pressure. The range of the instrument for accurate work is from 0·001 mm. to 3 or 4 mm. The instrument can also be used as a differential gauge with the same accuracy. In use the changes in pressure can be observed by the deflection of a beam of light and may be recorded by a photographic device. Curves are given from a photographic record of the action of the gauge during the release of CO_2 and water vapour which had been frozen out in a trap with liquid air. Attention is called to the rapidity with which this gauge responds to changes of pressure. AUTHORS.

975. *Exploration of the Deep Sea.* **H. Löwy.** (Phys. Zeits. 20. pp. 207–208, May 1, 1919.)—Describes by aid of diagrams the apparatus used to explore the ocean depths. E. H. B.

976. *Metrology in the Industries and the Universities.* **R. T. Glazebrook, P. E. Shaw, W. Ripper.** (Phys. Soc., Proc. 31. pp. 1*s*–29*s*, June, 1919. Discussion.)—No brief abstract is possible, but the tendency of the discussion was to show that the system of limit gauging must be used in the production of work in quantity, that interchangeable work is absolutely necessary, and that education, both of the workman and of the principal, as to the importance of the application of metrology, is urgently needed. L. H. W.

977. *On Aneroid Barometers.* **E. Warburg** and **W. Heuse.** (Zeits. Instrumentenk. 39. pp. 41–55, Feb., 1919. From the Physical.-Techn. Reichsanstalt.)—The general use of aneroids as altimeters, which involves the measurement of pressures varying from 760 to 400 mm. of mercury, and less, has resulted in a considerable amount of experimental work, with a view to the elimination of the "creep" or lag effect shown by all aneroids, which in practice is of considerable importance to pilots of aircraft.

The result of the present investigation is to emphasise the importance of three factors, if creep is to be reduced:—(1) The selection of metal with suitable properties for the manufacture of the aneroid boxes—namely, thin and hard nickel-silver. (2) The use of a strong counter spring, which shows scarcely any lag effect. (3) The use of two or more boxes, so as to reduce the amount of extension required of each box.

The application of these three factors has resulted in the production of aneroids which show a lag of no more than 2 mm. over the range 760 to 410 mm. of mercury. R. C.

978. *Mass of a Litre of Air under Normal Conditions.* **A. Leduc.** (Bureau Int. Poids et Mes., Mem. 16. [37 pp.] 1917.)—The author makes use of Regnault's method, using, however, glass bulbs of about 2300 cm.^{3} capacity which were fitted with glass stopcocks sealed directly on to them. Full details are given of the methods of determining the capacities, compressibilities and weights of the bulbs, and especially of the method of wiping them before weighing and allowance for any errors thereby caused.

The densities of various constituents of the atmosphere were first determined. Oxygen prepared by heating potassium permanganate and then purified and dried had a density of 1·10527 compared with the mean density of the air at Paris, whilst oxygen prepared by the electrolysis of sulphuric acid or potassium hydroxide solution had a density of 1·10521. The mean density is taken as 1·10523. Atmospheric nitrogen was obtained by passing purified and dried air over reduced copper heated to a low red heat. This temperature must not be exceeded, otherwise the nitrogen may be mixed with hydrogen which was retained by the copper when the oxide was reduced. At a low red-heat this hydrogen forms water with the oxygen of the air, so that the nitrogen must be dried before its density is determined. Nine determinations gave values for the density varying between 0·9719 and 0·9721, the mean value being taken as 0·97203. Chemical nitrogen was prepared (1) by heating ammonium nitrite and passing the gas over a heated mixture of copper and copper oxide; (2) by heating ammonium nitrate and then heating the nitrous oxide produced as in (1); (3) by passing nitric oxide over copper heated to incandescence. After appropriate purification the mean density was found to be 0·96717 with respect to air and 0·87508 with respect to oxygen. Argon, purified by passing over a heated mixture of calcium shavings and copper oxide, gave a density of 1·3787. Neon, after purification, was found to have a density of 0·695, whereas Ramsay and Travers give the value 0·674. The values taken for helium, krypton, and xenon were those given by Ramsay and Travers, 0·137, 2·818, and 4·422 respectively.

In dealing with a mixture of gases it is pointed out by the author that Dalton's law of partial pressures, as usually stated, is not correct, since gases do not conform absolutely to the gas laws. It should be enunciated as follows: *The volume occupied by a mixture of gases is equal to the sum of the volumes occupied by the individual gases at the same temperature and at the pressure of the mixture.* This is confirmed by experiments made on mixtures such as CO_2 and N_2O, CO_2 and SO_2, H_2 and SO_2. In the case of purified air, where the main constituents are very similar with respect to their physical properties, any corrections due to deviation from the law of partial pressures can be neglected.

Chemical analysis of the air investigated, which had been freed from moisture and CO_2, was made as follows: A glass bulb of about 2250 cm.^{3} capacity, containing phosphorus, was evacuated and weighed. Air was then admitted, and after keeping for about 20 hours the bulb was again weighed. It was then evacuated and weighed once more. From these weighings, after appropriate corrections have been made, the weight of air used and the weight of oxygen contained in it can be ascertained.

The mean composition of air at Paris, purified from aqueous vapour and gases absorbable by alkali, is as follows:—

	Oxygen.	Nitrogen.	Argon.	Neon.	Helium.	Hydrogen.	Krypton.	Xenon.
By volume ...	0·2100	0·7806	0·0094	15×10^{-6}	5×10^{-6}	1×10^{-6}	50×10^{-9}	6×10^{-9}
„ weight ...	0·2321	0·7549	0·0130	$8·4\times10^{-6}$	$0·7\times10^{-6}$	$0·07\times10^{-6}$	140×10^{-9}	30×10^{-9}

For such air at 0° and a pressure of 76 cm. of Hg at 0° at Paris the mass of 1 litre is found to be 1·2932 gm. Under normal pressure (76 cm. of Hg at 0°; $g=980·665$) the weight is 1·2928 gm. In other terms, taking the sp. gr. of mercury as 13·5951 and the value of g at the 4th story of the Sorbonne as 980·97, the mass of a litre of air under the pressure of a megabar is 1·2759 gm. The error is not greater than 1 in 25,000.

Air from various parts of France, the Alps, and Algiers, samples being taken both in the Spring and in the Winter, was investigated. The average weight percentage of oxygen was 23·20–23·21 %, extreme values being 23·05 and 23·25 %. The percentage is slightly lower in the North and at sea-level than elsewhere, and the author concludes that this would also be the case in London, so that systematic discrepancies between his results and those of Rayleigh could thus be explained. Samples of air taken in a balloon (height not stated) were less rich in oxygen than air at the level of the earth, but the differences were much less than would be expected by the law of Laplace.

T. S. P.

979. *Vibration and Strength of Struts and Continuous Beams under End Thrusts.* **W. L. Cowley** and **H. Levy.** (Roy. Soc., Proc. 95. pp. 440–457, June 4, 1919.)—An extension of previous work [see Abs. 890 (1918)] to the more general problem of the vibration of a continuous beam, simply supported at any number of non-collinear points, the external loading being a constant longitudinal end thrust, varying from bay to bay, and a periodic lateral loading. In addition the supports are assumed in a state of periodic vibration. These conditions correspond closely with those in a wing spar of an aeroplane when in actual flight and influenced by engine throbbing. A general form of the equation of three moments is derived, and the conditions for resonance and crippling are expressed in a convenient determinant form. The general equation where the restrictions are removed as regards the constancy of end thrust and of flexural rigidity in each bay is then treated, and applied to the particular case of the crippling of a strut of variable flexural rigidity.

J. W. T. W.

980. *Two-dimensional Solutions of Poisson's and Laplace's Equations.* **L. Bairstow** and **A. Berry.** (Roy. Soc., Proc. 95. pp. 457–475, June 4, 1919.)—Gives, in the first part, two-dimensional solutions of Poisson's and Laplace's equations as met with in problems arising from the torsion of solid or hollow cylinders, the flexure of beams, and the motion of non-viscid fluid round a cylinder. The method is of even more general application than the soap-film method used by Griffith and Taylor [Abs. 221 (1918)]. In the second part of the paper, the analytical solutions of some of the problems are obtained. J. W. T. W.

981. *Mechanical Properties of Steel, with some Consideration of the Question of Brittleness.* **W. H. Hatfield.** (Inst. Mech. Eng., J. No. 5. pp. 347–401; Disc., 402–482, June, and pp. 483–588, July, 1919. Engineering, 107. pp. 615–618, May 9; 634–636 and 638, May 16, and pp. 686–688, May 23, 1919.)—Deals with the different types of mechanical tests which have been devised for the testing of steel, including tensile, alternating, impact and hardness tests. Shows that each test gives some information of interest, but that such information needs careful consideration by the engineer in relation to the kind of work required. A distinction is drawn between real brittleness in a steel and apparent brittleness due to shape of test-piece or method of testing. Real brittleness is stated to be much less frequently met with than is generally imagined. The tensile test is considered to be fundamental, the other forms of mechanical testing being auxiliary and useful for supplementing our knowledge of steels when required for specific purposes. The investigation of failures is dealt with, and it is pointed out that the examination of similar samples which have done good service is often of great assistance. The mechanical properties of steels used for different purposes are discussed, and a table is given which summarises the tests for 11 different steels. Curves are given to illustrate the mechanical properties of a nickel-chrome steel in different states of hardness, in which the comparative values obtained under the tensile and torsion tests, Izod, Fremont, and Charpy impact tests, Stanton, Sankey and Arnold tests are given. An appendix gives the details of the various mechanical tests employed in the investigation, and a second appendix gives a bibliography of work published on Impact and Alternating-stress tests. C. O. B.

982. *Theory of Aron Meter: Note on Effect of Impulsive Forces in Pendulums.* **H. G. Rowledge.** (Electrician, 82. pp. 622–624, May 30, 1919.)—The effect of an irregularly varying attraction on the frequency of a pendulum is considered. The author concludes that such errors as may arise by using a pendulum to measure an irregular attraction are compensatory, and that in a large number of periods the compensation, by the law of averages, tends to become exact, so that the time-integral of the attraction is correctly registered by the oscillations of the pendulum. E. H. B.

983. *Strains in Glass due to Temperature Gradients.* **E. D. Williamson.** (Washington Acad. Sci., J. 9. pp. 209–217, April 19, 1919.)—Gives equations for the elastic stresses produced by temperature differences in spheres, cylinders, and slabs when the temperature distribution is symmetrical about the centre, axis, or central plane respectively. The specific forms of these equations for the special case of temperature distribution due to uniform surface heating, are also given. J. W. T. W.

984. *Irregularities of Motion of Foucault's Pendulum.* **A. C. Longden.** (Phys. Rev. 13. pp. 241–258, April, 1919.)—In a brief historical statement, emphasis is put upon the current opinion that a Foucault pendulum must be very long and very heavy in order to be successful. It is then shown that the elliptical motion so common in Foucault pendulum experiments is not due to insufficient length or weight, or even to atmospheric disturbances, but simply and solely to unequal freedom of motion in different directions. The

disturbing influences are within the pendulum itself. Different forms of support and suspension are discussed, and methods of eliminating the disturbing influences are suggested. What the author describes as a double roller support is shown to be superior to any other form of support thus far proposed. With this support and a perfectly annealed double bifilar suspension, a 2·5-metre pendulum of weight 1 kg. succeeds perfectly.
E. H. B.

985. *Proposed World-Network of Longitude and Latitude Stations.* **E. Picard, B. Baillaud,** and **Ferrié.** (Comptes Rendus, 168. pp. 1074–1076, June 2, 1919.)—The French Bureau des Longitudes proposes to take advantage of the great advances made during the war in wireless telegraphy to base a world survey on a tetrahedron of points: Paris, Shanghai, and a place near San Francisco in the Northern Hemisphere, and one in New Zealand in the Southern, employing intermediate wireless stations for clock comparisons, *e.g.*, Honolulu for Shanghai and San Francisco. Greenwich is suggested as an extra station, on account of the importance of old determinations based on it.

It is hoped to determine possible deformations of the earth from the tetrahedron.
W. W. B.

986. *Vortices in a Fluid Jet.* **L. Lecornu.** (Comptes Rendus, 168. pp. 923–926, May 12, 1919.)—Beltrami showed that if stream lines coincide with trajectories, the ratio of vortex velocity to stream-line velocity varies as the density. It is shown that a jet flows from a reservoir with steady motion is such a case. Although according to Lagrange's theorem the absence of vortices in the tank entails their absence in the jet, actually a very slow movement in the reservoirs would result in appreciable jet velocities. The ratio of vortex velocity to stream-line velocity is shown to depend on the form of the trajectory.
W. A. R.

987. *N. Bohr's Model Atom.* **W. H. Westphal.** (Deutsch. Phys. Gesell., Verh. 20. pp. 88–93, June 30, 1918.)—Defends the Bohr atom against a criticism by J. Stark.
E. H. B.

988. *Capillary Determination of Surface Tension.* **B. Thieme.** (Deutsch. Phys. Gesell., Verh. 18. pp. 414–422, Dec. 15, 1916.)—A criticism of the above method.
E. H. B.

989. *Mechanical Philosophy and Surface Tension.* **F. G. Edwards.** (Chem. News, 118. pp. 270–271, June 6, 1919.)—When an ether atom of mass $0·08 \times 10^{-24}$ gm. impinges upon a chemical atom of much larger mass the velocity of the ether atom is reduced in the proportion $fM/(M + m)$. Above the critical temperature and below the critical pressure of a gas, this would be compensated in the inverse ratio by the impact of a chemical atom upon an ether atom, so that the ether atoms in the interspaces of the gas would have the same average velocity as in the free ether. But immediately on the temperature being reduced and the pressure increased, the chemical atoms impinge upon each other to form the infinite molecule of the liquid or solid condition and the compensation of the ether atom is lost. This period corresponds with the formation of the meniscus in the vacuum tube or the tension surface surrounding the liquid. The work required to force an electron into a metal or out of a liquid is next shown to be a function of the surface tension, and in like manner contact potential is a function of the two surface tensions. The path of the ethereal atom is then shown to

coincide with the four edges of a regular tetrahedron, the atom thereby not reciprocating in a rectilinear path which would be the hypothetical alternative motion in a dodecahedral formation with double plena. Hitherto it has been deemed impossible to determine the intrinsic molecular pressure of water directly, but now it is shown that the accepted estimates of $1{\cdot}1 \times 10^{-10}$ dynes require to be multiplied by 41. If the intrinsic pressures, as now suggested, are exactly determined by the heat of neutralisation, the value of the unknown term $dp/d\mathrm{T}$ in the Clausius equation $dp/d\mathrm{T} = -\mathrm{L}/\mathrm{T}(v_2-v_1)$, can be calculated. Moreover, if the Eotvös formula be true, namely $\sigma\mathrm{M}/\rho^{2/3} = \mathrm{K}(\theta-6)$, the surface tension of a single molecule is obtainable with the weight of the molecule or molecular aggregate; and as the periodic specific volumes and the periodic specific entropies of the elements are measurable, they can all be shown to be functions of the atomic shapes, which recur in accordance with the periodic table when the chemical atoms are built up symmetrically with the ether atom as the tetrahedral unit. H. H. Ho.

990. *Mechanical Theories of the Electromagnetic Field.* XII. **A. Korn.** (Phys. Zeits. 20. pp. 85–88, Feb. 15, 1919.)—This paper proposes a new basis for the radiation theory. According to the electromagnetic and mechanical theories, the cause of radiation lies in the mechanical oscillation of electrical particles whose velocities are of the form:

$$u_0 = \Sigma_j[a_{j1} \cos (t/\tau_j)2\pi + a_{j2} \sin (t/\tau_j)2\pi] \ldots,$$

and the order of magnitude of τ_j determines whether the vibrations are Hertzian, infra-red, ordinary light, ultra-violet, etc. The author now deals with the dark radiation. If the distribution of oscillation energy be regarded rigidly from the standpoint of classical mechanics, then results in conflict with experience are obtained, while Planck with his modification by means of the quanta hypothesis brings about accord. The author now submits this problem to re-examination, and finds the relationship between the two hypotheses to be much more profound than had hitherto been regarded. By an investigation of the alternating-effect of the oscillating particles a radiation law has been derived which is compatible with experience. The transition from a velocity of one sign to its opposite, is shown to be the cause of radiation proceeding from the particle. The monochromatic oscillation energy for dark radiation is found to be proportional to

$$\nu^4 e^{-\beta\nu/\mathrm{T}})/[\mathrm{T}(1 - e^{\beta\nu/\mathrm{T}})^2],$$

while according to Planck it is proportional to $\nu^3/(e^{\beta\nu/\mathrm{T}} - 1)$.

The paper concludes the series of investigations into mechanical theories of the electro-magnetic field. H. H. Ho.

991. *The Arrangement of Electrons in Atoms and Molecules.* **I. Langmuir.** (Am. Chem. Soc., J. 41. pp. 868–934, June, 1919.)—The theory presented in this paper is essentially an extension of Lewis's theory of the "cubical atom." It may be most concisely stated in terms of the following postulates:—

(1) The electrons in atoms are either stationary or rotate, revolve or oscillate about definite positions in the atom. In the most stable atoms, namely those of the inert gases, the electrons have positions symmetrical with respect to a plane, called the equatorial plane, passing through the

nucleus at the centre of the atom. No electrons lie in the equatorial plane. There is an axis of symmetry (polar axis) perpendicular to this plane through which 4 secondary planes of symmetry pass forming angles of 45° with each other. These atoms thus have the symmetry of a tetragonal crystal.

(2) The electrons in any given atom are distributed through a series of concentric (nearly) spherical shells, all of equal thickness. Thus the mean radii of the shells form an arithmetic series 1, 2, 3, 4, and the effective areas are in the ratios $1 : 2^2 : 3^2 : 4^2$.

(3) Each shell is divided into cellular spaces or cells occupying equal areas in their respective shells and distributed over the surface of the shells according to the symmetry required by Postulate 1. The first shell thus contains 2 cells, the second 8, the third 18, and the fourth 32.

(4) Each of the cells in the first shell can contain only one electron, but each other cell can contain either one or two. All the inner shells must have their full quotas of electrons before the outside shell can contain any. No cell in the outside layer can contain two electrons until all the other cells in this layer contain at least one.

(5) Two electrons in the same cell do not repel nor attract one another with strong forces. This probably means that there is a magnetic attraction (Parson's magnetic theory) which nearly counteracts the electrostatic repulsion.

(6) When the number of electrons in the outside layer is small the arrangement of the electrons is determined by the (magnetic ?) attraction of the underlying electrons. But when the number of electrons increases, especially when the layer is nearly complete, the electrostatic repulsion of the underlying electrons and of those in the outside shell becomes predominant.

(7) The properties of the atoms are determined primarily by the number and arrangement of electrons in the outside shell and by the ease with which the atom is able to revert to more stable forms by giving up or taking up electrons.

(8) The stable and symmetrical arrangements of electrons corresponding to the inert gases are characterised by strong internal and weak external fields of force. The smaller the atomic number, the weaker the external field.

(9) The most stable arrangement of electrons is that of the pair in the helium atom. A stable pair may also be held by : (*a*) a single hydrogen nucleus ; (*b*) two hydrogen nuclei ; (*c*) a hydrogen nucleus and the kernel of another atom ; (*d*) two atomic kernels (very rare).

(10) The next most stable arrangement of electrons is the *octet*, that is a group of 8 electrons like that in the second shell of the neon atom. Any atom with atomic number less than 20, and which has more than 8 electrons in its outside layer tends to take up enough electrons to complete its octet.

(11) Two octets may hold one, two, or sometimes three pairs of electrons in common. One octet may share one, two, three, or four pairs of its electrons with one, two, three or four other octets. One or more pairs of electrons in an octet may be shared by the corresponding number of hydrogen nuclei. No electron can be shared by more than two octets.

This theory explains the periodic properties of all the elements, including those of the eighth group and the rare earths. It meets with success in explaining the magnetic properties of the elements, and applies as well to the so-called physical properties, such as boiling-points, freezing-points, electric conductivity, etc., as it does to the "chemical properties." AUTHOR.

992. *Note on the Ether Controversy.* **E. Budde.** (Deutsch. Phys. Gesell., Verh. 21. 5 and 6. pp. 125–126, March 30, 1919.)—To the author it appears as if through the whole of the literature dealing with the ether controversy, which begins with the Lorentz-Stokes polemic and is resumed later in Einstein's treatise on the electrodynamics of moving bodies [see Abs. 2277 (1905)], a confusion reigns which must first be eliminated before a sound estimate can be formed of the various views *pro* and *con.* He points out that the properties of the electromagnetic field must not be postulated for the ether, and that Michelson's experiment, as also observations on the aberration and Doppler phenomena in stars, only admit conclusions with respect to the electromagnetic field, which are essentially different from those of its substantial substratum. Other examples of like confusion are discussed. H. H. Ho.

993. *The Atomistic Ether, the Hydrogen Atom, and the Planck Active Quantum.* **L. Zehnder.** (Deutsch. Phys. Gesell., Verh. 21. 5 and 6. pp. 118–125, March 30, 1919.)—During recent years the ether hypothesis has again come to the fore, and various hypotheses are mentioned by the author, notably that of Witte, who shows that a homogeneous space-filling ether cannot explain optical and electrical processes; and that of Lenard, who gives an atomic structure to the ether. Lenard's ether atoms, the dynamids, recall Kelvin's vortex atoms, although they differ essentially from these. Lenard's ether hypothesis is exceedingly complicated in contrast to that proposed by the present author, which he claims cannot be excelled in simplicity, clarity, and probability. The latter hypothesis only necessitates a single distance force, namely, gravitation, while all other hypotheses involve several such forces. Also no reversals of recognised fundamental physical laws are involved as with Bohr's atomic model and other modern theories. Nevertheless the simplicity and clarity of his ether hypothesis appear fatal to the author, since the history of Physics is full of similar abortive examples. Notwithstanding, the author is of opinion that the simplest possible ether hypothesis should be investigated as far as its most extreme consequences before more complex hypotheses are put forward.

According to the author's presentation, the ether is a substance like all others, being made up of the smallest particles designated "ether-atoms," as a distinction from ordinary elementary atoms. These ether-atoms are extremely small relative to the element atoms, but, like them, possess weight and are perfectly elastic. Their velocities are of the order of light and within the universe is no ether vacuum. In spite of the enormous velocities it is shown that every element atom has its ethereal envelope, as also the molecules and combinations arising from atoms and molecules. A full discussion of the properties of this ether is given, from which the author concludes that electricity is none other than the heat of the ether; light corresponds to sound in the ether, while electrical potential is the temperature of the ether. The electron is regarded as a definite large number of ether atoms with a large ethereal heat, and possesses an apparent mass which is greater the more rapid the velocity of the electron. The hydrogen atom, which is the simplest elementary atom, is most probably spherical and consists of a spherical atomic nucleus of completely elastic substance surrounded by an ether envelope which is elastic but not completely so, because it consists of ether atoms compressed together, whereby damped oscillations and other motions can ensue. The radiation of radio-active substances is dealt with at some length, as also the problem of spectral ines. The Bohr atomic model is explained as a system of electrical oscillations. A discussion of Planck's active quantum h concludes the paper, this quantity being regarded throughout as a universal constant. H. H. Ho.

994. *The Origin of Anticyclones and Depressions.* **J. Logie.** (Roy. Soc. Edinburgh, Proc. 89. pp. 56–77, 1918–1919.)—The paper develops the author's idea that the chief cause of depressions and anticyclones is to be sought in radiation and that convection and surface friction are of much less importance than is generally supposed. It is demonstrated that if the air temperature over a certain region "A" between the levels $h=x$ and $h=y$ is increased while the temperature over another region in the neighbourhood "C" is decreased, the temperature at all other levels and places remaining unaltered, then over "A" in a layer above the level $h=x$ (the lower of the two levels) the pressure will immediately be increased, the density reduced and the entropy increased, the changes over "C" being of opposite sign. Below the level $h=x$ pressure, etc., remain unaltered. In the layer above $h=x$ where the pressure changes have occurred anticyclonic and cyclonic circulation will in consequence set in. The second stage in the process is then entered upon. This depends upon the fact here demonstrated that in any fluid in motion denser portions tend to move towards regions of high pressure and rarer portions towards regions of low pressure. This leads to an accumulation of air over "A" (pressure high) and a deficit of air over "B," so that the anticyclone and depression become extended to the surface. The distribution of pressure and temperature at different levels in the anticyclone and depression deduced from this theory are found to agree well with the mean figures determined by W. H. Dines. The temperature-changes required for the production of the pressure systems may be set up by (1) movement in latitude, (2) the formation of extensive cloud screens, (3) changes of diathermancy due to the formation of thin haze, etc. Whereas according to the old idea the cause of a depression was to be found in the convection of *heated* air, the theory here set out ascribes it to an initial *cooling* of the air. J. S. Di.

995. *"Storms of Cold" and their Paths.* **A. Baldit.** (Comptes Rendus, 168. pp. 623–625, March 24, 1919.)—Thunderstorms are usually divided into two classes, (*a*) heat storms and (*b*) storms in depressions. The former are usually local in character, the latter accompany line-squalls which are experienced in the southern sectors of depressions. The author describes a third type of thunderstorm, namely, "storm of cold," which occurs in a cold zone of air advancing from the north into a region where temperature is high, and upper winds are from the south. In these circumstances cumulo-nimbus clouds developing into thunderstorms are formed on the southern boundary of the cold wave, and are carried northwards by the upper south wind in a direction opposite to that of the north wind at the surface. Thus the storms travel backwards through the zone of cold air. R. C.

996. *The Investigation of the Atmosphere in Cloudy or Thick Weather.* **H. Löwy.** (Phys. Zeits. 20. pp. 175–183, April 15, 1919.)—The paper describes first of all, methods for obtaining observations of wind-velocity and direction in the upper air by various means which are effective in thick or cloudy weather. One method consists in noting the times of arrival of sounds produced by successive explosions at prearranged intervals at the positions which a free balloon rising steadily takes up at those intervals, and deducing therefrom the velocity and direction of the air layers through which it passes. Another is to observe the position at which a shell, fired at a known muzzle velocity and altitude, is seen to emerge from the clouds. Successive shells fired at gradually increasing velocities provide data for the exploration of the wind in successive heights. The computations for both of these methods become very laborious as the height increases, and even for low heights are much more complicated than the corresponding computations for the method of pilot balloons, which can, however, only be used in clear weather. Suggestions are also made for obtaining a record of temperature and pressure at different heights by means of projectiles. R. C.

997. *The Application of Observations of Upper Winds to the Forecasting of Changes of Pressure.* **L. Dunoyer** and **G. Reboul.** (Comptes Rendus, 168. pp. 785–787, April 14, 1919.)—The following general rules were deduced after a study of observations of wind in the upper air made with pilot balloons. (1) When successive ascents reveal strong winds aloft or winds of which the velocity is progressively increasing, a fall of pressure is likely. (2) When successive ascents reveal feeble winds aloft, or winds of which the velocity is progressively diminishing, a rise of pressure is likely. (3) When the winds aloft are homogeneous and have not changed for several hours, pressure is unlikely to change. Similarly if the upper winds at any level show a marked increase in velocity in course of time, a fall of pressure is likely: while if those winds show a marked decrease in course of time a rise of pressure is likely. (Errata. *Ibid.*, p. 832, April 22, 1919.) R. C.

998. *Some Examples of the "Compression of a Cyclone."* **G. Guilbert.** (Comptes Rendus, 168. pp. 691–693, March 31, 1919.)—The author gives concrete cases of the application of one of his general rules for weather forecasting, which is as follows: Every depression which is surrounded on all sides by "convergent" winds of which the velocities are abnormal by excess, will fill up *in situ* within 24 hours—sometimes within 12 hours—with high pressure in the middle of the former depression. R. C.

999. *Preliminary Reflections on the General Circulation of the Atmosphere.* **H. H. Hildebrandsson.** (Comptes Rendus, 168. pp. 593–598, March 24, 1919.)—The following general statements descriptive of the general circulation of the atmosphere are derived from actual observations, without the application of any preconceived ideas: (1) A mighty current blowing from the East girdles the earth around the thermal equator. Its velocity is small at the surface, but is consistently high (34 m/sec.) in the upper layers. (2) In temperate latitudes the general current is, on the other hand, from West to East. (3) In the upper layers currents are deviated to the right in the northern, and to the left in the southern hemisphere. Consequently the easterly current at the Equator is gradually deviated through South to West as one passes northwards from the Equator to sub-tropical latitudes, and through North to West as one passes from the Equator southwards. These westerly winds feed the sub-tropical high-pressure systems. (4) The sub-tropical high-pressure systems give rise near the surface to the NE. Trade Winds in the northern hemisphere and the SE. Trade Winds in the southern; also to the SW. and NW. winds of the temperate latitudes of the northern and southern hemispheres. (5) The monsoons do not partake of the general circulation, since they are not found above 4500 m. Beyond that height the East and West winds of the general scheme are found according to the latitude. (6) In the polar regions surface winds are usually from the East and upper winds from the West (NW. to SW.). (7) The greater the height, the greater is the constancy of West winds in temperate latitudes; whence it is concluded that cyclones and anticyclones originate in the lower layers. (8) Thus there is no upper current blowing directly from the Equator to the poles, nor is there a lower direct current from poles to Equator. (9) There is, however, a slow exchange of air between poles and Equator taking place along the meridians, due to North and South currents on the front and rear of cyclones and anticyclones, and to upward and downward motion.

Halley's theory of the general circulation is thus incompatible with fact. The author sets out certain facts which appear to explain in a general qualitative way the facts as above set out. The two most important of these facts are: (1) Hadley's proposition that moving air is continuously deflected to the right in the northern, to the left in the southern hemisphere with an acceleration proportional to the sine of the latitude. (2) Ascending currents are carried from the East to the West, and descending currents from West to East, with an acceleration proportional to the cosine of the latitude.

R. C.

1000. *A Method of Measuring Visibility.* **A. Wigand.** (Phys. Zeits. 20, pp. 151–160, April 1, 1919.)—An instrument is described consisting of seven circular transparent glasses, mounted around a rotating disc attached to a frame, which can be fitted over the observer's eye in such a way that the glasses can be brought successively across the field of view while the eye is sheltered from stray side-light. The glasses vary regularly in opacity and are numbered 2, 4, 6, 8, 10, 12, and 14 respectively corresponding to the degree of opacity on an arbitrary but fixed scale. A rotating arm mounted on the axis of the disc carries another transparent glass of which the opacity is 1 on the same scale, so that an observer can interpose an opacity corresponding with any whole number from 1 to 15 between his eye and an object. Definite objects having been selected at various known distances from the observer, the method of observation is to select that transparent glass through which an object can just be seen, and to name as corresponding opacity given by the instrument the number of the glass next higher on the scale, through which the object is invisible. Experiment has shown that on a day of max. visibility the mean opacity number of the instrument is 14·8. If a is the opacity number on any occasion, $14{\cdot}8 - a$ is a measure of the lack of transparency of the atmosphere for the particular object seen, and $(14{\cdot}8 - a)/l$, where l is the distance of the object, is a measure of the lack of transparency of the air for unit distance of the object. The reciprocal of this, namely, $l/(14{\cdot}8 - a)$ is defined as the visibility (*Sicht*) of the air. Certain precautions required for making an observation, a list of causes of deterioration of visibility, and a number of actual observations are also given, together with a diagram which serves for the rapid evaluation of the above quantity for different values of a and l.

R. C.

1001. *Simple Form of Apparatus for Estimating the Oxygen Content of Air from the Upper Atmosphere.* **F. W. Aston.** (Chem. Soc. J., Trans. 115, pp. 472–475, May, 1919.)—In the apparatus described a sample of about 10 cm.^{3} of air is drawn into a burette and by adjustment of a mercury column is compressed or expanded slightly so as to occupy a standard volume. The height of the mercury column is marked and the air then withdrawn and deoxidised by means of heated phosphorus. It is again drawn into the measuring apparatus and made to occupy a volume which is equal to 79 % of that previously occupied by it. The difference of pressure from the former value is noted. As normal air contains 21 % oxygen the second pressure will be approximately equal to the first, and it is the difference between the two which indicates the departure of the oxygen content of the sample from that of normal air. 3 mm. pressure-difference on the mercury column corresponds with 1 % difference in oxygen content and readings can be obtained to 1/20th of a mm., or 1/60th of 1 %. The results of a test on a known sample of air (20·42 % of oxygen) are given. The value obtained by the use of the apparatus was 20·39 %. J. S. Di.

1002. *Surface Reflection of Earthquake Waves.* **G. W. Walker.** (Roy. Soc., Phil. Trans. 218. pp. 373–393, June 12, 1919.)—In addition to primary features—the arrival of longitudinal and transverse waves—a seismogram may show sharp impulses which, according to Weichert, represent the arrival of waves that have undergone one or more reflections at the earth's surface. Reflection of longitudinal and transverse waves at an ideal plane surface is analysed by the author, and the theoretical results are compared with observation. (1) *Longitudinal Waves.*—The relative magnitude of a longitudinal disturbance reflected a number of times may be determined by two circumstances. These may be, firstly, a reduction of amplitude due to spherical divergence and general scattering as the wave proceeds through the earth—this factor is at present difficult to deal with but in the author's opinion not of much importance. Secondly, there is a sudden change of amplitude at each reflection. On comparing calculated values for the times and magnitudes of disturbances of waves reflected at different epicentral distances with observation, there is a partial agreement with the theory, and the discrepancies are not accidental. The difference suggests the desirability of investigating reflection from a layer of variable thickness comparable with that of the earth's crust. (2) *For Transverse Waves,* vibrations in the azimuth plane, observed results are in general agreement with the reflection theory. (3) *Wechselwellen* (*i.e.,* waves that have changed from longitudinal to transverse, and *vice versa*) are probably not clearly separated from the transverse until the distance exceeds 9000 km., and are perhaps readily mistaken for the transverse waves themselves. If so, the question is raised whether the marked periodicity usually associated with the transverse waves at shorter distances is not really due to *Wecheselwellen* coming earlier than present time-curves suggest. In conclusion, quantitative analysis of the reflection theory on simple lines removes a number of difficulties that have hitherto attended the interpretation of seismograms. W. A. R.

1003. *The 15-month Earthquake Period.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 79. pp. 461–466, April, 1919.)—Tables of analyses of Hirota's *Catalogue of Chinese Earthquakes* are given, and show a period of about 14·84 months with variations, in a cycle of 78 years. W. A. R.

1004. *Determination of the Setting Error of an Equatorial by Differential Measurements.* **W. Gyllenberg.** (Ark. för Mat. Astron. och Fysik Stockholm. 13. No. 9. [pp. 1–9, in German], 1918.)—The author's method here described is for use with instruments in which the readings on the hour circle or declination circle cannot be taken with sufficient accuracy for his earlier method to be used (Lund Observatory Meddel. No. 72). In the new method the movable cross of the filar micrometer is directed on to a star whose position is known approximately. The clock is then started, and after a given time the star has moved from its position, partly in Right Ascension and partly in Declination. The star is brought back to the cross centre by means of the micrometer screw, and the readings give the displacements. From a series of such readings the difference in Declination is derived. The error due to instrumental flexure is assumed to be zero. L. H. W.

1005. *Pulkova Pole Oscillations and a Systematic Influence.* **R. Schumann.** (Akad. Wiss. Wien, Ber. 126. 2a. pp. 1167–1191, 1917.)—The author's investigation is only put forward as a contribution to the knowledge on the subject: no definite result is arrived at. But he points out that even the newer Pulkova series of observations are influenced in a systematic manner by certain causes which have up till now defied explanation.

L. H. W.

1006. *Earth Effect on the Sun.* **J. Evershed.** (Nature, 103. p. 272, June 5, 1919.)—At Kodaikanal Observatory the spectrum of Venus has been photographed, in order to test whether a displacement of solar lines towards the red can be due to an earth-effect, since the said displacement varies with distance from the centre of the disc. The author considers that the results prove that the effect is not due, as suggested by G. T. Walker, to relativity, but thinks that it is probably due to the earth, though independent confirmation is still required. W. W. B.

1007. *Meudon Observations Relating to the Eclipse of May 29.* **H. Deslandres.** (Comptes Rendus, 168. pp. 1076–1080, June 2, 1919.)—The Observatory was unable to send its usual expedition to observe the eclipse, on account of the war, and for the same reason has not for some time been supplied with the large glass plates for the use of the photoheliograph. A preliminary note is given dealing with a small spot and filaments with associated protuberances, visible about the time of the eclipse, of which a fuller account will appear later. During the eclipse wireless signals from the British station at Ascension which normally only reach Meudon at night, were heard distinctly, and the time when they gradually became inaudible again is expected to throw light on the effect of solar radiation upon the transmission of Hertzian waves. W. W. B.

1008. *Proper Motion of Nova Aquilæ No. 3.* **R. Trumpler.** (Astron. J. 32. pp. 61–63, June 11, 1919.)—From a comparison between Allegheny plates of Nova Aquilæ after the outburst with Algiers Astrographic plates showing it in its faint previous existence, 25 years earlier, a proper-motion has been deduced of $+ 0{\cdot}0003^s$ in R.A. and $- 0{\cdot}004''$ in Declination. The Nova was also shown on parallax plates taken at Allegheny in 1914.

The resulting centennial P.M. is $1{\cdot}85''$ in position-angle 194°. Van Rhijn's tables suggest that the parallax of a star with such P.M. is $+ 0{\cdot}003''$. The nova would appear to have been about as bright as the sun before the outburst which sent it up to a brightness 100,000 times as great. W. W. B.

1009. *On the Physical Theory of Cometary Tails.* **F. Zerner.** (Phys. Zeits. 20. pp. 93–94, Feb. 15, 1919.)—In discussing the different hypotheses which have been put forward to account for the motion of cometary tails (radiation-pressure, etc.) the author refers to the difficulty of accounting for Schmidt's nebulosity, investigated by Hepperger (K. Akad. Wien, Ber.

87. p. 603, 1883), who showed that the western part of the nebulous mass, which had broken loose from the comet, was subjected to a repulsive force due to the sun, whilst the eastern part was subjected to an *increased attraction* on the part of the sun. He now suggests that if the particles forming the nebulous mass are of dimensions 10^{-5} cm., the effect may be due to the presence of light-positive and light-negative particles among them, giving rise to Ehrenhaft's "photophoresis" [see Abs. 1085 (1918)]. L. H. W.

1010. *Studies of Colours and Magnitudes in Stellar Clusters.* XI. *A Comparison of Distances of Celestial Objects.* **H. Shapley.** (Mt. Wilson Solar Observat., Contrib. No. 156. Astrophys. J. 49. pp. 249–265, May, 1919.)—In continuation of previous papers [Abs. 34, 418 (1919)], this is an endeavour to show by scale the great range of distances of certain definite groups of objects, from the comparatively near Hyades to the most distant globular cluster, which is given as N.G.C. 7006 at 67,000 parsecs, or nearly 220,000 light-years. This cluster is compared with nearer clusters, but appears to differ only in distance, not in colour nor in frequency of red giant stars. On the other hand, the cluster N.G.C. 4147, the most distant from the galactic plane, may differ from typical clusters both in frequency of giant stars and also in linear extent which in the typical clusters points to a diameter exceeding twenty million astronomical units.

The selective scattering of light in space makes very little difference to the colour index of distant stars brighter than 15th magnitude.

It is doubtful whether ω Centauri or 47 Tucanæ is the nearest globular cluster; some of the results are provisional, but it appears that the two Magellanic clouds are at distances of the same order though they differ in size.

A special study of the numerous faint variables of the Orion nebula leaves the question unsettled as to whether they really belong to the nebula. If they do they are very much fainter than other variables and are possibly in a pre-giant stage. W. W. B.

1011. *Correlation Between Colour-Scales of One and Two Dimensions.* **J. G. Hagen.** (Astrophys. J. 49. pp. 282–285, May, 1919.)—3162 stars have been observed by Franks on the two-dimension scale and by Krüger and Osthoff on the one-dimension scale; these will appear in a forthcoming publication of the Vatican Observatory, and provide the author with a means of comparing the two scales, one of which ranges from bluish-white, white, yellowish-white, and so on to orange-red, red, and dark-red, while the other goes from —1, 0, 1 to 10.

Of the 3162 stars 2498 are yellowish, 576 orange, including orange-yellow and orange-red, and 88 peculiar, including green and violet. The comparison brings out several points of personality in different observers, and suggestions are made in the direction of allowing a simpler correlation between the two scales. The 88 stars given as peculiar by Franks give a mean impression on Krüger and Osthoff of 2.73 which corresponds to pale yellow. The author admits the advantage in their case of the two-dimensional system, but thinks that in general, and especially in such a case as Nova Aquilæ, a numerical scale is preferable, which can be reduced by a step-correction and colour-correction to make one observer's figures comparable with those of another. W. W. B.

1012. *Spiral Orbits in Gravitational Equilibrium.* **E. Belot.** (Comptes Rendus, 168. pp. 835–937, May 12, 1919.)—On the hypothesis that the planetary system had its origin in a collision between a primitive solar body and a nebula, the author shows that the ordinary parabolic velocity due to gravitation, being only 4 or 5 km., as against a velocity of 800 km. in the Andromeda nebula, is negligible in comparison with velocities due to collisions. But going on to consider possibilities other than the closed curves of the solar system, he shows that gravitational equilibrium, *i.e.*, a condition in which gravity at every point exactly balances the centrifugal force, is possible in a logarithmic spiral, and finds the limiting value of the resistance of the medium which determines whether the spiral shall be centripetal or centrifugal. W. W. B.

1013. *Green Colour of Nova Aquilæ.* **J. Lunt.** (Observatory, No. 540. p. 248, June, 1919.)—The H-lines having faded considerably, most of the light in April came from the two chief nebular lines and the nebular band near H_γ, so that the star appears green in the telescope. The enhanced Ti spectrum of the early stages of the nova indicated a very high temperature and as nebulium is considered by Nicholson to be a very simple type of atom of low atomic weight, the author suggests that it may be a gaseous product of disintegration of a more complex atom, just as He is derived from radium. W. W. B.

1014. *Parallax of Pleiades.* **W. J. A. Schouten.** (Observatory, No. 540. pp. 240–245, June, 1919.)—Employing a method previously explained [Abs. 158 (1919)], the author obtains a parallax of 0·036″, and discusses the values previously obtained by Wolf, Charlier, Gaultier, Lagrula, and Hnatek. He considers that Schiller's and Dugan's catalogues of the Pleiades do not contain stars belonging to the cluster, which he thinks includes no star fainter than 11th magnitude, so that the range is from 4½ to 11 apparent magnitude, or 2·3 to 8·8 absolute. He also refers to determinations by Kapteyn and Plummer which suggest a parallax of the same order of magnitude. His parallax of 0·036″ corresponds to a distance of 88 light-years. W. W. B.

LIGHT.

1015. *Stellar Spectrograph of the 72-inch Reflecting Telescope.* **J. S. Plaskett.** (Astrophys. J. 49. pp. 209–228, May, 1919.)—The great Dominion reflector, when arranged as a Cassegrain for spectrographic purposes, has an equivalent focal length of 108 ft., the Cassegrain mirror being 20 in. in diameter. The max. longitudinal aberration of the principal mirror at constant temperature is 0·25 mm., but a daytime rise of 5 deg. C. increases this to 3 mm.; hence heat-insulating covers have been applied completely encircling the mirror, and have reduced this to 0·5 mm., the error in all cases being of under-correction. The figure of the Cassegrain mirror is also very good; under average conditions the circle of confusion is 0·05 mm. in diameter. The arrangements for setting are very convenient, only two or three minutes being required between an exposure on one star and on another. The moving parts weigh 45 tons. The author gives a full explanation of the reason for the spectrograph being of the "Universal" type in contrast with the rigid fixed form in use for the Mills spectrograph at Lick, the Bruce at Yerkes, and the Hartmann at Potsdam, which had apparently superseded the old Universal form. A long collimator, 2½-in. aperture and 45 in. focal length is employed, and prisms of O 118, in preference to O 102 (which were considered too absorbing), were ordered from Jena but, naturally, have not been delivered. A Hilger 60°-prism of the same aperture and material has been lent by Toronto University. The central ray is placed at λ4200, much nearer the violet than has usually been possible. The objectives are all triple, but Canada balsam has not been used as a cement for fear of strains; so to avoid internal reflections between surfaces a film of watch-oil is placed between.

Equally full details are given of the slit and accessories, the spectrograph box (of aluminium), the temperature case, the link-work for minimum deviation, and the arrangements for using one or more prisms, and for taking spectra side by side on one plate.

The temperature case is heated by passing the 110-volt lighting current through wires sewed to the felt lining. The current being turned on and off by a mercury-contact thermometer actuating a relay, enables the temperature to be kept as a rule within a range of 0·1 deg. C. for a night. A Callendar recorder is proposed to keep account of the working of the thermostatic arrangements.

No parts of the spectrum between λ3900 and λ4600 need be more than 0·05 mm. out of focus. 1300 spectra of stars, mostly fainter than 6·0 magnitude, have been photographed with a single-prism and a medium-focus camera, giving a dispersion at $H\gamma$ of 35Å. per mm. Under average conditions, the spectrum of a 7th magnitude star can be obtained in 20 to 25 mins. With a good silver coat and good seeing this could be reduced to 15 mins. The probable error of radial velocities with a single prism is for stars F to M-type well under 1 km., being ±0·85 km. on the average for G-, K- and M-stars.

Since 3-prism spectra require 5 times the exposure of single-prism spectra, the author considers that for fainter stars the latter method is preferable.

W. W. B.

1016. *Doppler-effect in the Molecular Scattering of Radiation.* **C. V. Raman and J. Larmor.** (Nature, 103. pp. 165–166, May 1, 1919.)—Larmor

[Abs. 279 (1919)] has put forward the suggestion that the additive property of the energy elements scattered by the individual molecules of a gas is secured by the irregular alterations in the wave-length of the scattered radiation produced (in accordance with Doppler's principle) by the thermal movements of the molecules. Raman here points out that the magnitude of the Doppler-effect would depend on the angle between the primary and scattered radiation, and would, in fact, practically vanish in directions nearly the same as that of the primary waves. The importance of this becomes evident if we attempt to explain refractivity on the basis of molecular scattering. This appears possible only if the energy effects due to the individual molecules are not additive in directions nearly the same as that of the primary wave, and the vanishing of the Doppler-effect in the scattered radiation would seem to be a necessary condition for mutual interference of the radiations from individual molecules to be possible.

Larmor states that the point raised by Raman had been noted by Rayleigh, and was mentioned very cursorily in his recent paper [Abs. 279 (1919)]. In directions that are nearly coincident with the transmitted ray there can be no sensible dispersal of phase, either from thermal motion of the molecules or from irregularity of their spacing. Disturbances, therefore, completely conspire, and the light scattered by the molecules in such directions is specially favoured. Each molecule will exert its full effect on the index of refraction, however irregular the distribution may be, provided the medium is not so dense that the molecules will obstruct each other, and, moreover, the thermal motions will not disturb this effect. The specially favoured directions, for disturbances passed on by the molecules, must be almost coincident with the ray. A. W.

1017. *Scattering of Light by Carbon Particles in a Luminous Flame.* **H. Senftleben** and **[Miss] E. Benedict.** (Deutsch. Phys. Gesell., Verh. 21. pp. 144–148, April 30, 1919.)—Experimental investigation of the properties of luminous flames, shows that such flames behave in an exactly similar manner to turbid media, and the results obtained for absorption and reflection by the luminous carbon particles are found to be both qualitatively and quantitatively in agreement with Mie's theory of turbid media [Abs. 594 (1908)]. From absorption measurements an estimate was obtained of the number of luminous particles per unit volume, the value found being $9{\cdot}6 \times 10^{9}$, which is in agreement with Becker's result [Abs. 1067 (1909)]. [See Abs. 2045 (1906) and 513 (1918).] A. W.

1018. *Scattering of Light by Solid Substances.* **R. J. Strutt.** (Roy. Soc., Proc. 95. pp. 476–479, June 4, 1919.)—Numerous specimens of plate glass and optical glass have been examined. These all show the scattering, though they differ among themselves in respect of intensity and completeness of polarisation. No special arrangements are necessary to observe the scattering. If a narrow parallel beam, say 6 mm. in diam., from the condenser of an electric lantern, is allowed to traverse the interior of a block of glass, the scattered light along the track will be conspicuous. Glass scatters very freely, the scattered light being blue, and in many cases almost completely polarised. The depth and purity of the blue colour depends, of course, on the completeness of polarisation. A few comparisons were made between the intensities of vibration in the scattered light: (1) parallel to the direction of the primary beam (weak image); and (2) perpendicular to the primary beam (strong image). The former is given as a percentage of the latter. The result for Chance's crown glass was about 8 %, and for ordinary plate glass 3 %. The Chance's crown gives a much poorer blue. These glasses give a degree of polarisation of the same order as the various gases where the scattering is molecular. This, however, is probably an accidental circumstance. In the case of glasses, the wide difference between different samples suggests that scattering is due mainly to inclusions rather than to the molecules. These inclusions are probably to be regarded as spherical, some of them with a diameter not small compared with the wave-length. In this case the defect of polarisation in glass would be due to the appreciable size of the obstacles, whereas in gases it is due to lack of spherical symmetry. It was found that yellow quartz and smoky quartz scatter light very strongly, the colouring matter being evidently distributed in the crystal in the form of small particles analogous to those found in glass. With a crystal of yellow quartz from Madagascar, the polarisation was almost complete, the weak image about 0·7 % of the intensity of the strong one. If the incident light is polarised, and the line of vision is along the axis of the crystal, the cloud of particles acts as an analyser, and as the beam advances into the crystal, the plane of polarisation is rotated, so that alternations of light and darkness are observed laterally, corresponding to rotations of 90°. In white light, the rotatory dispersion gives striking coloured bands, similar to interference bands, and like them rapidly losing purity after a few periods, owing to the superposition of different orders. Visually, five or six periods can be traced. Photographs of these bands are reproduced. A specimen of colourless quartz gave less scattering than any glass, or any specimen of water or liquid ether that has been examined. Intensity comparisons of the total light scattered by clear quartz, and by other media, gave the following results: Dust-free air, 1; clear quartz, 8; plate glass, 300; liquid ether, 900. Scattering has also been observed in a clear crystal of Iceland spar. The scattering was strong compared with air. [See Abs. 835 (1918).] A. W.

1019. *Ultra-violet and Visible Transmission of Eye-protective Glasses.* **K. S. Gibson** and **H. J. McNicholas.** (Bureau of Standards, Technol. Papers, No. 119. [47 pp.] Washington, 1919.)—The paper contains data on thickness, colour, transmission percentage throughout spectrum from 280 μμ–700 μμ, and total transmission factor, for 82 samples of eye-protective glass. In the early part of the paper the terms used are explained; the types of spectrophotometers used in the work are also mentioned. In the appendix the transmission curves for the various glasses are reproduced and three forms, suitable for use in the specification of eye-protective glasses, with a view to avoiding excess of heat, ultra-violet or visible energy are suggested. Several combinations of glasses have excellent protective properties. J. S. D.

1020. *Glasses for Protecting the Eyes from Injurious Radiations.* **W. W. Coblentz** and **W. B. Emerson.** (Bureau of Standards, Technol. Papers, No. 93. [25 pp.], Washington, 1919.)—The paper contains a survey of a considerable number of newly developed glasses for protecting the eyes from radiant energy—ultra-violet, visible, or infra-red. Diagrams are presented showing the transmission of ocular media. The authors then deal successively with yellow glasses, Crookes glasses (including sage-green and neutral-tinted types), and various glasses for absorbing infra-red (gold-plated, blue-green, greenish brown and black). Finally certain miscellaneous glasses are described. In each case curves showing the distribution of energy throughout the spectrum are presented. By using combinations of these glasses suitable protection against excess of infra-red, visible or ultra-violet light, coupled with sufficient visibility can be obtained in most classes of work. J. S. D.

1021. *Impurities and the Milkiness of Optical Glass.* **C. N. Fenner, J. B. Ferguson,** and **F. Gelstharp.** (Am. Ceramic Soc., J. 1. pp. 468–476, July, and pp. 559–566, Nov., 1918.)—Co-operating with the Bausch and Lomb Optical Co. in the manufacture of optical glass the Geophysical Laboratory was chiefly troubled by the opalescence and milkiness of certain glasses. The milkiness never showed in samples taken out of the furnace, but appeared later, sometimes only after cooling. The same trouble had been noticed by Cauwood and Turner [Abs. 490 (1917)] and had by them been attributed to the use of impure Russian potash, containing chloride and sulphate in varying quantities, instead of the formerly used pure German potash, and had been cured by them by heating the glass to high temperature. This is on the whole confirmed. Heating for 36 hours altogether (melting and fining) to a little above 1400° C. prevented milkiness in the presence of 0·8% SO_3, and heating for 9 hours to 1420 and 1430°, combined with good stirring, even with 0·7 SO_3; the chloride is not so injurious. But it is not clear in what way the sulphate causes milkiness, and in some cases As_2O_3 and CaF_2 seemed likewise to favour milkiness, which was further observed in CaO-MgO-SiO_2 glasses. With the American potash, purer than the Russian, little difficulty was experienced. It is suggested that the sulphate and chloride give rise to some slight change as to physical properties of the melt which permits the separation of clouds of minute crystals of cristobalite. Gelstharp does not consider the responsibility of sulphate and chloride as established. The optical glass made by the Pittsburg Plate Glass Co. has been free of milkiness except in the case of one borosilicate crown and one dense flint, in which the injurious feature seems to be the volatilisation of alkali leaving a supersaturated solution silica which separates on reheating the glass. In reply, **Fenner** and **Ferguson** point out that they do not ascribe all milkiness to sulphate, and that with proper temperature control the trouble disappeared. H. B.

1022. *Constant-deviation Prisms.* **E. Bloch.** (J. de Physique, 7. pp. 145–151, July–Aug., 1917.)—This paper gives a geometrical treatment of the theory of constant-deviation prisms, considering first the general case of prisms with any value for the constant deviation and then making particular application to the Pellin-Broca prism [Abs. 1480 (1899)]. The simple geometrical treatment will replace the analytical method of Uhler. If the Pellin-Broca prism be denoted by ABA′B′, where AB is the incidence face, BA′ the face where the rays are internally reflected, and AB′ the emergence face, A being a right angle, it is shown that the point S, where the bisector of the angle A meets the side BA′, is an invariable point; and if the prism be turned about an axis through S, the incident ray remaining fixed, the emergent ray is also fixed in position. There is no other axis of rotation which possesses this property. The distance BS is given by $BS = a \sin \frac{1}{2}A / \sin (B + \frac{1}{2}A)$, where $AB = a$. Putting $A = 90°$ and $B = 75°$, this gives $BS = 0{\cdot}816a$. For a certain fluorine prism, suitable for the extreme ultra-violet, $AB = a = 23$ mm.; $BA' = 28$ mm., and the distance $BS = 18{\cdot}8$ mm. In the Schumann region, between the wave-lengths 0·185 *u* and 0·180 μ, the index of fluorine increases from 1·50 to about 1·70. The extreme values of the angle of incidence, calculated by Descartes' formula, are therefore about 48° 30′ and 58° 12′. The usable widths of the incident beam thus vary from 15·3 mm. to 12·2 mm., and those of the emergent beam from 9·8 mm. to 7·8 mm. The beam is thus appreciably more reduced in width than in height. In the prism in question the height was 25 mm. It is consequently necessary, in order to get the rays in the correct position on the photographic plate, to adjust the position of the axis of rotation as accurately as possible, and to use only the centre of the image in order to avoid errors due to astigmatism. A. W.

1023. *Superposed or Duplicated Spectrum Fringes.* **C. Barus.** (Nat. Acad. Sci., Proc. 5. pp. 149–152, May, 1919.)—A method of producing bright spectrum fringes with any slit width. J. W. T. W.

1024. *Design and Inspection of Optical Munitions.* **A. C. Williams.** (Optical Soc., Trans. 20. pp. 97–120, Jan., 1919.)—Describes the methods adopted at Woolwich for testing the various optical instruments used in quantity during the war. These include telescopes, periscopes, dial sights, clinometers, bubbles, rangefinders, mirrors for heliographs, etc.

J. W. T. W.

1025. *Invisible Light in Warfare.* **R. W. Wood.** (Phys. Soc., Proc. 31. pp. 232–238, June, 1919.)—One device was a signalling lamp consisting of a 6-volt electric lamp with a small curled-up filament, at the focus of a lens of about 3 in. diam. and 12 in. focal length. This gives a very narrow beam, only visible in the neighbourhood of the observation post to which the signals are directed. Other devices are also described. E. H. B.

1026. *Geometrical Coordination of Vectors concerned in the Structure and Propagation of Light.* **A. Guillet.** (J. de Physique, 7. pp. 184–208, Sept.–Oct., 1917.)—A geometrical treatment of the various wave surfaces for crystals and the vectors involved. E. H. B.

1027. *Velocity of Light in Turbid Media.* **C. Chéneveau** and **R. Audubert.** (Comptes Rendus, 168. pp. 937–939, May 12, 1919.)—Additional details showing a good agreement between calculation and experiment.

E. H. B.

1028. *Theory of Surface Layers.* **H. Schulz.** (Deutsch. Phys. Gesell., Verh. 18. pp. 384–396, Nov. 15, 1916.)—Mathematical treatment and historical review of the problem of light reflection when the transition from one medium to the other is not quite sudden. E. H. B.

1029. *Colour of Colloidal Gold Solutions.* **B. Pogány.** (Deutsch. Phys. Gesell., Verh. 18. pp. 298–301, June 30, 1916.)—Determines the metal constants of thin gold layers from 1 $\mu\mu$ to 1·5 $\mu\mu$ thick as functions of the thickness. The results are given in tables and curves. [See Abs. 594 and 1272 (1908).] E. H. B.

1030. *The Bleaching of Coloured Papers by Daylight.* **O. Meissner.** (Phys. Zeits. 20. pp. 210–211, May 1, 1919.)—Seven strips of paper, of dark (blue, red, brown) and light (red, orange, yellow, green) colours were glued on cardboard, partly covered with cardboard and exposed to daylight for

nearly one month (Sept.–Oct.) between double windows; measurements were then made after Ostwald [Abs. 926 (1917)]. In the dark colours the blackness increased and the whiteness decreased, but the tone was hardly changed; in the light colours the purity decreased from 35 to 60 % to about 20 %, both the blackness and whiteness increasing to a fairly equal degree.
H. B.

1031. *The Colours of Colloids.* IV. *Interference and Diffraction.* **W. D. Bancroft.** (J. Phys. Chem. 23. pp. 253–282, April, and pp. 289–347, May, 1919.)—An interesting collection of facts relating to the colours of thin plates obtained from published work. No brief abstract would be of value. [See Abs. 574 (1919).]
L. H. W.

1032. *Glass Making before and during the War.* **H. J. Powell.** (Soc. Arts, J. 67. pp. 485–493; Disc., 493–495, June 13, 1919.)—A general description of the state of the glass-making industry before the war, and of the developments which have taken place during the past five years.
J. W. T. W.

1033. *Transmission of Coloured Light through Fog.* **C. L. Utterback.** (Am. Illum. Eng. Soc., Trans. 14. pp. 133–140; Disc., 140–145, April, 1919.)—Describes experiments on light of different colours to determine the relative proportions transmitted through an artificially produced fog obtained by sudden expansion of moist air. The results obtained show a max. transmission for light of 5800 to 5900 μμ.
J. W. T. W.

1034. *A New Yellow Dye for Filters.* **C. E. K. Mees and H. T. Clarke.** (Eastman Kodak Co.'s Research Lab., Comm. No. 75. Frank. Inst., J. 187. p. 633, May, 1919. Abstract.)—The dyes previously used for making light-filters were principally picric acid, tartrazine, and Filter Yellow. Picric acid, while having a satisfactory absorption, is unstable, and as a consequence the early gelatine filters were made chiefly with tartrazine, which is quite stable. Tartrazine, however, has the disadvantage that it transmits the ultra-violet and that filters made from it are relatively inefficient. The introduction of Filter Yellow in 1907 supplied a dye having a good absorption in the ultra-violet, reasonably sharp-cut in the spectrum and of great stability. It was still desirable for high efficiency, especially in filters for aerial photography, that a dye should be obtained possessing the stability and ultra-violet absorption of Filter Yellow but with greater sharpness of cut. The compounds of phenyl hydrazine with sugars are yellow in colour and a soluble compound of this type has been prepared by coupling glucose with *para*-hydrazine-benzoic acid. The sodium salt of glucose-phenyl-osazone-*para*-carboxylic acid prepared in this way, proving to be a very suitable dye for the preparation of sharp-cut light filters, has been given the name of "Eastman Yellow." From this new dye light-filters have been prepared under the designation of EK–1 and EK–2 filters, which are stable to light, have a very strong absorption for ultra-violet, and are considerably sharper and more efficient than K filters made from Filter Yellow.
A. E. G.

1035. *Colour Values in Monochrome—A New Viewing Filter to Assist in obtaining them.* **F. F. Renwick.** (Phot. J. 59. pp. 158–169; Disc., 169–172, May, 1919.)—The *macula lutea*, or yellow spot, includes the whole region of clear vision within which careful comparison is possible without movement of the eye; it is the colour-sensitiveness of this area, therefore, which must be taken as the standard. Now, since the spectrum of white daylight includes light of every wave-length to which the eye is sensitive, it is clear that all visible colours may be regarded as white light minus one or more of its constituents, and since it has been experimentally proved that the luminosity of every colour is equal to the sum of the luminosities of its components, it follows that if we know the relative luminosities of all the colours of the spectrum of white light the relative luminosities of all other (compound) colours depend only on their spectral compositions. The final conclusion reached as the result of the work done on colour vision by Koenig, Abney, Watson, Ives, Nutting, and others is that for bright illuminations the retina of the normal eye in the region of clear vision is most sensitive to light of frequency 541×10^{12} vibrations per sec. (equivalent to wave-length 555 $\mu\mu$), the sensitiveness falling off symmetrically on either side of this frequency in accordance with the following empirical equation: $V = e^{-0\cdot0002064}(f - 541)^2$, where V is the ratio of visibility at frequency f to the max. visibility at frequency 541. This result refers, however, to the retinal layer itself, after allowance has been made for the selective absorption of the yellow pigment and other media overlying it and also it refers to light of equal power throughout the spectrum. Owing, however, to the presence of the yellow pigment and other absorbing media through which the light reaches the retina, the curve of visibility no longer remains quite symmetrical when we are dealing with the natural eye, the luminosity at the blue end of the spectrum being a little depressed by their selective absorption. Moreover, average noonday sunlight at the earth's surface does not possess equal power throughout the spectrum, the intensity at the blue-violet end varying for the same time of day about 30 to 40 % owing to changes of atmospheric conditions. Nevertheless, it remains substantially true that the relative luminosities throughout the spectrum of average daylight can be fairly represented by a symmetrical curve rather like a round-topped spurwheel tooth in shape with its maximum at wave-length 555 $\mu\mu$ in the green. Further, it remains fairly true for many sources of white light which give a continuous spectrum (open arc, tungsten filament lamps, etc.) if the invisible ultra-violet region is ignored, except that the position of the maximum is somewhat shifted towards the red in these cases.

For a uniformly sensitive panchromatic plate it is shown that a strong green filter is the only one which can lay any claim to be a perfect correcting filter for all colours, and inasmuch as recent advances in the production of panchromatic plates have resulted in the realisation of equal sensitiveness in the red and blue of the spectrum of arc light, with the green not far behind, it is evident that for the best work in monochrome a green filter is now absolutely essential. A filter for observation purposes having absorption coefficients corresponding to the inverse of, *i.e.*, complementary to, the perfect correction filter, for any given panchromatic plate, will reduce the luminosities of every part of the visible spectrum of white light to correspond to the sensitiveness of the plate to the same light. Hence such a filter will so alter the appearance of any coloured scene or object that its apparent tone values will now agree with those which the panchromatic plate would register. With a properly balanced filter the kind of record the unscreened plate would give can be seen beforehand, and by adding any desired yellow, orange, or other filter to it the effect of such filter on the rendering of the tone values of the scene by the plate can be studied. To make a filter of the kind described is not easy. The range of suitable dyes is not sufficient. It is difficult to find dyes having the required absorptions, or to compound a filter from a mixture of dyes to get the desired result; there is also the further question of the permanency of the dyes to be considered.

A. E. G.

1036. *Artificially Dichroic Liquids.* **W. B. v. Czudnochowski.** (Deutsch. Phys. Gesell., Verh. 18. pp. 360–363, Sept. 30, 1916.)—Describes two very simple arrangements for showing this effect, using alternately for the illumination of the liquid a frosted glow-lamp and a De la Rive fluorescence apparatus. The liquids employed are (1) a mixture of fluorescein and methyl violet, (2) aesculin solution (extract from horse-chestnut rind). With solution (1) the colour transmitted is violet and the fluorescence colour yellow-green; with solution (2) the colours are respectively wine-red and blue.

L. H. W.

1037. *New Polariser.* **G. Brodsky.** (Phys. Soc., Proc. 31. p. 230; Disc., 230–231, June, 1919.)—This consists of a pile of glass plates placed between two prisms of the same glass in such a manner as to (*a*) reduce the length of the polariser by one-half; (*b*) utilise the full aperture of the pile; and (*c*) get rid of *all* reflected light. The device is patented (Brit. Pat. 121,906).

E. H. B.

1038. *Length of Rulings of a Concave Grating in Relation to its Resolving Power.* **M. Kiuti.** (Phys. Math. Soc. Japan, Proc. 1. pp. 96–111, May, 1919.)—Nagaoka has pointed out that rulings long compared with the grating space give rise to deterioration of resolution of the closely situated components of a complex line [see Abs. 1387 (1916)]. The present paper examines the question further, and formulæ are obtained for the resolving power of a concave grating in a Rowland or Littrow mounting, account being taken of the length of the rulings.

A. W.

1039. *Band Spectra.* **T. Okaya.** (Phys. Math. Soc. Japan, Proc. 1. pp. 111–121, May, 1919.)—This paper gives a discussion of the relation between the heads of band spectra belonging to different elements of the same group. It is shown that, for the three elements Au, Cu, and Ag, the wave-length of the heads of the bands emitted by their molecules satisfies fairly well the linear relation $\lambda = \alpha + \beta n$, where α and β are constants and n is the series of natural numbers. From this it is concluded that between the heads of the band spectra emitted by the different molecules in similar conditions there exists a simple relation when the bands diverge towards the red side. Thus, the wave-length λ of the head of some band of one element with reference to the corresponding one λ' of another element is given by the relation $\lambda = (\alpha + \beta n)(m/m')^{1/2}(p/q)^{3/2}$, p and q being certain smaller integers, m and m' the atomic weights of the elements concerned, and $\lambda' = (\alpha + \beta n)$.

A. W.

1040. *Origin of Spectra and Planck's Law.* **J. J. Thomson.** (Phil. Mag. 37. pp. 419–446, April, 1919.)—Assume an atom with alternating attraction and repulsion at atomic distances, merging into the inverse square at large distances from the atom, *e.g.*, as if the force expansion contained the factor $\sin cu/cu$, where $u = 1/r$, and r is the distance from the centre, for which there would be equilibrium positions within the atom given by $r = c/n\pi$, where n is an integer. Then even with one +-charge and one electron there may be a single infinite series of atoms at central distances $r = c/n\pi$, which could give rise to an infinity of lines both in the absorption and emission spectra, the brightness of any line varying with the number of atoms of its frequency. Physical or chemical transformation of atoms from one kind to another is then possible; *e.g.*, if an atom with the electron at P were ionised it would become positively charged and attract an electron from outside which might settle at another equilibrium point Q, producing a different kind of atom. Such atoms would differ in other ways than frequency, *e.g.*, in specific inductive capacity, so that the proportion of different kinds would vary in different parts of a varying electric field; and they might differ in chemical combining power, so giving rise to variation in the spectra of an element with the character of the salt employed. Assume, further, that inside the atom there is a magnetic as well as an electric field and that the magnetic force is predominant in determining the frequencies. Then, if of the type inside a uniformly charged sphere rotating like a rigid body, a series of the Balmer type results.

The atomic model is thus a field of electric force which may be regarded as made up of a series of shells alternately of attractive and repulsive force, the radii of their boundaries, on which an electron would be in equilibrium, being in harmonical progression, and superposed on the field of electric force is a field of magnetic force, also arranged in shells, the outer boundary of the magnetic field coinciding with a place where the electric force vanishes. Where such an atom is exposed to strong electric charges or other methods of producing spectra, the outer layers of the magnetic field might become detached and its boundary so approach the centre, giving rise to what might be termed magnetic ionisation of the atom, which would resume its normal state on cessation of the exciting influence. The atoms in a luminous gas would then possess a double manifoldness, from varying positions of the electrons in the atom and from variation in the magnetic boundary. The first would give rise to lines in the same series, the second to a number of series mostly emitted only by the atoms produced by electric discharge. In an atom with more than one electron the equilibrium positions would be where this force at any electron balances the repulsion due to the other electrons. It is shown that such an atom gives rise to principal and subordinate spectral series all obeying the Rydberg-Schuster frequency law. It is shown that pairs or triplets may be anticipated when the electrons in a ring are asymmetric with respect to the centre; that the observed difference in the behaviour of the frequencies in the two kinds of series are accounted for; and that the line of longer wave-length in a principal-series pair is analogous to that of shorter wave-length in a first subordinate series, which explains the observed behaviour of the pair in alkali metal spectra. The assumption of the simple relation between the electric and magnetic forces $B = 2\pi m/h \,.\, \int pd/ds(\omega R)ds$, where ds is an element of a line of electric force, ω the cross-section of a tube of force, m the mass of an electron, h Planck's constant, and p determined by the equation $dp/ds = -1/\omega$, leads to the result that if an electron falls from a place where the magnetic force vanishes to another position of equilibrium, the frequency is w/h, where w is the energy converted into radiation. Thus the transference from potential energy to energy of radiation is in accordance with Planck's law, and a physical concept of the quantum theory is obtained. It is easy, on this assumption, to find laws of electric force such that the frequencies of electrons would be connected by a relation similar to that expressed by a Rydberg series, and the consideration of an example of this suggests the possibility of the existence of an universal constant, of dimensions representing the moment of an electric doublet, which would involve the conclusion that electric doublets of constant moments form a part either of the atoms of all elements or else of the medium surrounding them. The value of this possible universal constant which would make the numerical constants of the series agree with Bohr's theory, which gives values for the frequencies agreeing with observation, and also with the values calculated from the ionisation potential of the H atom, to the order of the probable experimental error in determining the latter. According to the view here considered, the excitation of a gas spectrum by the impact of kathode rays is due, not chiefly to the ejection of electrons from the atom, but to the return to the ionised gas of slow-speed electrons produced by atomic ionisation, and the energy which is converted into radiation is that which these electrons acquire in falling into positions of equilibrium. From some experiments on the radiation due to bombardment by kathode rays, the author concludes that by far the larger part of the radiant energy is concentrated in radiation of definite wave-lengths as if a mixture of definite types ($a, b, c, \ldots$) of characteristic radiations were emitted by the target, the type a being excited only when the kathode-ray energy exceeded e_1, b when it exceeded e_2, and so on. It is shown that if spectral lines arise from the effect of magnetic forces, they may be expected to consist of trains containing a very large number of wave-lengths, the number being inversely proportional to the frequency. Photoelectric effects and ionisation, produced by the passage of a stream of radiation through metals and gases respectively, are discussed and accounted for on the resonance view that when an electron absorbs radiant energy it is a constituent of a system in which it vibrates in unison with the radiation, which requires concentration of the energy of the light-wave in certain places instead of uniform distribution over the wave-front. But it has the great advantage of accounting for the electrical effects of light without introducing changes in our conception of light which give rise to difficulties with ordinary optical effects such as interference or scattering, which are not affected by the resonance hypothesis, and an analytical examination leads to the conclusion that there does not appear to be anything in the scattering of light by the atoms of a gas or in the rotation of the plane of polarisation of light inconsistent with the existence of a strong magnetic field within the atom. The theoretical conclusions are in accordance with the known properties of Röntgen radiation. G. W. de T.

1041. *The Logarithmic Law Connecting Atomic Number and Frequency Differences in Spectral Series.* **G. A. Anslow.** (Phys. Rev. 13. pp. 326–336, May, 1919.)—In continuation of a previous note by Anslow and Howell, graphic and algebraic relations are derived between the logarithms of the atomic numbers and of the ν, $\nu_1 + \nu_2$, ν_1 and ν_2 constant frequency-differences occurring in the spectral series of alternate members of the same chemical family. Two systems of four approximately straight lines approaching parallelism resulted when a family possessed both doublet and triplet series. The equations derived are of the form $\nu = (\mathrm{N}/mnk)^{\mathrm{A}}$, where N is the atomic number of the element; A is a constant depending upon the system; n is an integer, the same for both systems in the same family; k is a constant, 0·080; and m takes on successive integral values for the ν, $\nu_1 + \nu_2$, and ν_1 equations. The agreement between the calculated and observed values of frequency differences indicates that the logarithmic lines should curve upwards for elements of high atomic number. The equations derived and the fact that an approximate linear relation seems to exist between the convergence frequencies of members of the same system of series and their atomic numbers do not seem to follow from the Bohr-Sommerfeld theory of atomic structure as so far developed and indicate that some adjustments to the theory are necessary if it is to be extended to predict optical series.

AUTHOR.

1042. *Arc Spectrum of Scandium.* **W. Crookes.** (Roy. Soc., Proc. 95. pp. 438–439, June 4, 1919.)—A quantity of pure scandia was prepared from the mineral wilkite, and this was finely powdered, mixed with a certain proportion of finely-divided silver and compressed into rods by means of a hydraulic press. These rods were then used to obtain the combined arc spectra of scandium and silver. On the same film were projected the combined scandium-silver spectrum, the spectrum of pure silver and that of iron. Thus the lines due to scandium could be easily identified, and their wave-lengths obtained by comparison with the iron lines. A table is given of 101 scandium lines, the wave-lengths ranging from λ2420 to λ6805, and photographs are reproduced.

A. W.

1043. *Series Spectrum of Helium.* **A. Landé.** (Phys. Zeits. 20. pp. 228–234, May 15, 1919.)—A theoretical discussion of the helium atom, based on Bohr's atomic theory, allows calculations to be made of the oscillation frequencies of series lines in the helium spectrum. The results obtained are tabulated and compared with experimental values. The results are in better agreement with Sommerfeld's model helium atom than with Bohr's, as they support the view that the He atom has two associated electrons with different orbital radii.

A. W.

1044. *Constitution of the Atom and Band Spectra.* **H. Deslandres.** (Comptes Rendus, 168. pp. 861–868, May 5, 1919.)—A discussion of the work of various experimenters leads to the conclusion that band spectra can be generally represented by the following formula, which, though more or less a first approximation, is usually very nearly correct:

$$\nu = \pm \tfrac{1}{2} f(n^2 p^2)(m + \alpha)^2 + \tfrac{1}{2}\mathrm{B}(n + \beta)^2 - \tfrac{1}{2}\mathrm{C}(p + \gamma)^2 \pm \mathrm{K}.$$

The whole number m has all values from unity upwards, sometimes reaching 160. The heads of the bands are represented by the last three terms. Numerical examples are given for the first groups of nitrogen, cyanogen, and carbon, for aluminium and for lead. The whole numbers n and p, in all these spectra, are large; they are always above 30 and may be over 200. The bearing of band spectra on various atomic theories is dealt with, and a subsequent paper will discuss the agreement of the known facts concerning band spectra with the different model atoms proposed up to the present.

(Errata. *Ibid.* p. 1168, June 10, 1919.) A. W.

1045. *The Mathematical Structure of Band Series.* II. **R. T. Birge.** (Phys. Rev. 13. pp. 360–378, May, 1919.)—In the first article of this series [Abs. 1356 (1917)], the author proposed a hyperbolic formula, for the accurate representation of long band series. The present paper initiates a more general discussion of this formula, and of the experimental results which the author has since obtained. Detailed analytic work has shown the new formula accurate, within limits of experimental error, for those band series showing the most radical deviations from the simple Deslandres' law. Preliminary work indicates that the hyperbolic formula is equally satisfactory in the case of series showing positive deviations from Deslandres' law, instead of the customary negative deviations.

A complete investigation of any band series is greatly facilitated by a preliminary study of its deviations from Deslandres' law. New methods have accordingly been developed for making this comparison in a rapid, yet accurate manner. In particular, there is developed a new Least Squares' formula, giving directly the value of the only desired constant in a Deslandres' formula, thus avoiding the more extended calculations necessary when all three constants are simultaneously evaluated.

A comparative study of band and line series formulæ suggests for band series a modified hyperbolic formula. This modified formula has been tested on several series, and has been found very satisfactory. New line series formnlæ are also suggested, but are not seriously recommended at this time. [See also Abs. 525 (1918).] AUTHOR.

1046. *Effect of Electric Field on Spectral Lines.* IX. **J. Stark** and **O. Hardtke.** (Ann. d. Physik, 58. 8. pp. 712–722, May 27, 1919.)—The Zeeman-effect for corresponding lines of similar series of different elements is the same both qualitatively and quantitatively. The question arises as to whether the same holds good for the Stark-effect. Already it has been found that the helium and lithium lines have a simple relation. The effect of the electric field on corresponding lines of these two elements is practically the same, both as regards the number and distance apart of the components. The present paper deals with the question as to whether this agreement holds also for the doublet series of other elements. The diffuse subordinate series of Na, Cu, Ag, and Al were examined, and the results show that there is a great difference in the behaviour of the Al lines and those of Na, Cu, and Ag. For the three latter the separation is of the same order of magnitude (1 to 3 Å.U. for 28,000 volts/cm.), but for Al the effect is much smaller, being less than 0·07 Å.U. for the same field strength. This latter result is in agreement with results previously given by Wetzel. A. W.

1047. *Stark-effect.* X. **J. Stark.** (Ann. d. Physik, 58. 8. pp. 723–730, May 27, 1919.)—This paper deals with the relations existing between the series of a single element, and is a continuation of work previously published [Abs. 1252, 1253 (1918)]. A discussion of the relation of the four subordinate series of hydrogen to the Balmer series, leads to similar relations for the helium series. The whole system of series (groups of four each of the first, second, and third orders) is arranged in tabular form, and formulæ assigned to them, the scheme being based on the Rydberg-Ritz combination principle. The bearing of the results on the theory of atomic structure is then briefly discussed. A. W.

1048. *The Ultra-violet Band of Ammonia, and its Occurrence in the Solar Spectrum.* **A. Fowler** and **C. C. L. Gregory.** (Roy. Soc., Phil. Trans. 218. pp. 351–372, June 5, 1919.)—The full paper corresponding to Abs. 937 (1918).

1049. *Spectrum Analysis aud Atomic Structure.* **J. J. Thomson.** (Engineering, 107. pp. 366–367, March 21; 410–411, March 28; 442–444, April 4; 476–478, April 11; 511–512, April 18, and pp. 562–565, May 2, 1919. Lectures delivered before the Roy. Inst. Electrician, 82. pp. 379–380, April 4; 473, April 18; 497, April 25; 519, May 2; 544–545, May 9, and pp. 573–574, May 16, 1919).

1050. *The Limiting Absorption Frequencies for X-rays of the Heavier Elements, with Special Reference to the Rare Earths.* **M. Siegbahn** and **E. Jönsson.** (Phys. Zeits. 20. pp. 251–256, June 1, 1919.)—After discussing the question from an historical standpoint the authors describe in detail a specially designed X-ray spectrograph for use in this investigation. The results of their observations on the elements Ag—Ur are given in the following table:—

Element.	N	de Broglie. λ	E. Wagner. λ	Blake and Duane. λ	Siegbahn and Jönsson. λ	Siegbahn and Jönsson. $\sqrt{(1/\lambda)}$
Ag	47	0·482	0·490	0·4850		
Cd	48	0·460	0·468	0·4632	0·4629	1·470
In	49			0·4434		
Sn	50	0·421	0·425	0·4242	0·4231	1·537
Sb	51	0·401	0·405	0·4065		
Te	52	0·385	0·383	0·3896	0·3877	1·606
I	53	0·369	0·369	0·3727	0·3715	1·641
Cs	55	0·340		0·3444	0·3436	1·706
Ba	56	0·327	0·331	0·3307	0·3306	1·739
La	57	0·313		0·3188	0·3186	1·772
Ce	58	0·300	(0·298)	0·3078	0·3064	1·807
Pr	59				0·2946	1·843
Nd	60		0·282		0·2835	1·878
Sa	62				0·2636	1·948
Eu	63				0·2543	1·983
Cd	64				0·2456	2·018
Dy	66				0·2294	2·088
Ho	67				0·2214	2·125
Pt	78	0·152			0·1578	2·518
Au	79	0·149			0·1524	2·561
Hg	80	0·146			0·1479	2·601
Tl	81	0·142			0·1427	2·647
Pb	82	0·138			0·1385	2·687
Bi	83	0·133			0·1346	2·725
Th	90				0·1127	2·979
U	92				0·1048	3·089

It will be seen from this table that the values of the limiting frequency λ, obtained by the authors, are in good accord with those of other observers. The values of $\sqrt{(1/\lambda)}$ and N given in this table are shown graphically, the elements Ag(47) to Ho(67) lying on a straight line, whilst the heavier elements, Pt(78) to U(92), are indicated by points lying above this straight line ($\sqrt{1/\lambda}$ ordinates). A. B. W.

1051. *Bohr's Frequency-Law and X-ray Line Spectra.* **A. Smekal.** (Deutsch. Phys. Gesell., Verh. 21. pp. 149–158, April, 30, 1919.)—A discussion of Bohr's frequency law in relation to the K- and L-series of the X-ray spectra of the elements. A. B. W.

1052. *May Refractive Indices of Bodies for Röntgen Rays be Experimentally Determined?* **A. Einstein.** (Deutsch. Phys. Gesell., Verh. 20. pp. 86–87, June 30, 1918.)—Expresses the hope that the subject may be attacked, possibly by a total reflection method. E. H. B.

RADIO-ACTIVITY.

1053. *Measurement of Radium Emanation in the Atmosphere.* **J. Olujić.** (Jahrb. d. Radioakt. 15. pp. 158–194, July 25, 1918. Dissertation, Freiburg, Switzerland.)—The author discusses the methods of Satterly (1908) and I. R. Wright and O. F. Smith (1914 and 1915) and gives the values of his observations (under Gockel) conducted at Freiburg, Feb. to Oct., 1917. His maximum, 805×10^{-18} curie per cm.^{3} of air, is somewhat higher than those of other observers in various localities; his minimum is 54, average 181. The special feature is the connection between the radium emanation and the meteorological conditions. H. B.

1054. *Diffusion of Radium Emanation into Water.* **E. Ramstedt.** (Nobel Inst., Meddel. 5, No. 5 [Arrhenius Festskrift]. [14 pp.] 1919.)—The rate of diffusion of radium emanation into water has been studied by F. Wallstabe [Abs. 3197 (1904)] who found for the coefficient of diffusion, D, the value 0·066 cm.^{2}/day, which, after correction for later determinations of the period of decay of emanation, is equivalent to 0·070 cm.^{2}/day. Similar experiments were made by Jahn (Dissertation, Halle 1914), who obtained a value $D = 0{\cdot}199$ at 16° in a solution containing 10 % gelatin, and $D = 0{\cdot}401$ in a 2·5 % solution of gelatin. It is clear from these results that gelatin reduces the rate of diffusion. A careful description follows of the author's method of experiment and calculation of the diffusion constant. The mean value of the coefficient D now determined is given as 0·820 cm.^{2}/day at 14°. This gives for the product $D\sqrt{m}$ the value 12·2 at 14°, and for the molecular radius of the radium emanation $1{\cdot}85 \times 10^{-8}$ cm. A. B. W.

1055. *Radio-activity in Natural Sardinian Materials.* **A. Serra.** (Soc. Chim. Ital., Gazzetta, 47. ii. pp. 41–5, 1917.)—A Sardinian porphyritic granite is found to be radio-active, its activity being $\alpha = 0{\cdot}00010$. The activity is shown to be due to the presence in the rock of uraniferous biotite; the biotite has been subjected to the action of water which has previously traversed strata of uraniferous mica, the thickness of the latter determining the greater or less radio-active power. T. H. P.

1056. *Ionisation by Collision.* **B. Bianu.** (Le Radium, 11. pp. 195–197, May, 1919.)—In studying the ionisation effects in water-vapour by the α-rays from polonium and in tracing the saturation curve, the author observed a marked disagreement between theory and experiment. [See Abs. 1542 (1914).] The author attributes the discrepancies to ionisation by collision, and in the present paper, deals with the question on the lines indicated by Townsend ("Theory of Ionisation of Gases by Collision") for the production of ions by collision in the case of a gas contained between two parallel plates of metal. It is shown to be necessary to distinguish between the various methods of producing the ions between the plates. Thus X-rays and β-rays produced a more uniform distribution of ions than α-rays—in the latter case the ions are very dense along the α-rays tracks and relatively scarce in other regions.

The author makes a careful study of this question and gives curves and tables of results in illustration of the points raised in the paper. A. B. W.

HEAT.

1057. *The Interferometer for Measuring Small Dilatations.* **C. G. Peters.** (Washington Acad. Sci., J. 9. pp. 281–284, May 19, 1919.)—An improved form of Fizeau's interferometer consists of three coned pins, 4 mm. across the base, 10 mm. long. Three conical holes, 0·5 mm. diam., 0·2 mm. deep, 15 mm. apart are drilled in the lower surface of the cover-glass plate. The pins rest on the lower glass plate. These holes keep the pins in place and stop any creep of the cover glass and also serve as reference marks in determinations of the change of length of the pins. The fringes formed by interference are viewed by a Pulfrich interferometer.

The theory, which is given, is simple. The apparatus was used at the Bureau of Standards to measure the differences in the thermal expansion of steel, copper and brass samples, for the temperature interval 0°-100.° It is also used for investigating the thermal expansion, and change in length when setting, of dental materials. P. E. S.

1058. *Determination of the Boiling-point of Sulphur by means of the Nitrogen Thermometer.* **P. Chappius.** (Bureau Int. Poids et Mes., Mem. 16. [44 pp.], 1917.)—The constant-volume gas thermometer used was made of fused silica, the bulb having a capacity of approximately 247 cm³. The nitrogen with which it was filled was made from a mixture (in solution) of sodium nitrite, ammonium sulphate and potassium chromate and was purified by washing with a mixture of potassium dichromate and sulphuric acid and then with potassium hydroxide. The coefficient (β) of increase of pressure at constant volume of the gas between 0° and 100° was found to be 0·0036699, and this coefficient was made use of in determining the boiling-point of sulphur by measuring the increase in pressure, for constant volume, when the thermometer bulb was immersed in the vapour of boiling sulphur. The absolute boiling-point under normal pressure was then found to be 444·60°. In a second series β was found to be 0·00366943, the b. pt. then being 444·60°, and in a 3rd series β had a value of 0·00366959, the b. pt. being 444·56°. Allowing for various corrections the final value for the boiling-point of sulphur at normal pressure is taken as 444·60° in the thermodynamic scale.

The details of the apparatus used and corrections made can only be appreciated by reference to the original paper. T. S. P

1059. *The Specific Heat of Tungsten at Incandescent Temperatures.* **P. F. Gaehr.** (Phys. Rev. 11. pp. 396–423, Nov., 1918.)—(1) A method used and described by Worthing has been slightly altered by using a cyclic method. The chief advantage is a saving of time in making the measurements. Details have been worked out for making the method accurate, and the method has been found satisfactory provided the battery and the driving mechanism function properly.

(2) It is shown that unless special precautions are taken, the pyrometric determination of instantaneous temperatures is not practicable. This point is to be taken up later.

(3) A variable resistance standard and a deflection potentiometer are

described, both of which are desirable in pyrometric work, especially when one has to work alone.

(4) A second method has been worked out, differing from Corbino's bridge method in two important details: (*a*) It is adapted to lamps with potential leads, and (*b*) the procedure is so modified as to simplify the measurements and calculations. This second method appears to render somewhat more consistent results, although, like the first method, differences in the specific heat appear when computed with increasing and decreasing temperatures, these differences being greater at the lower currents. But the constancy of battery e.m.f. is required over time-intervals of only 15 minutes, while the first method requires a constant battery for the duration of the entire run.

AUTHOR.

1060. *Latent Heats of Fusion and Molecular Composition.* **H. G. Wayling.** (Phil. Mag. 37. pp. 495–497, May, 1919.)—Discusses the rule formulated by Trouton in 1884, and which is now put in the following form:—

$$\frac{\text{Latent heat of fusion} \times \text{Molecular number}}{\text{Melting-point on absolute scale}} = \begin{array}{c}\text{Number of atoms}\\ \text{in the molecules.}\end{array}$$

This is tested by reference to a number of substances for most of which it is approximately correct. Thus for water $80 \times (2+8)/273 = 2{\cdot}93$ or 3 nearly. The molecular number is the sum of Moseley's atomic numbers of the atoms in the molecule.

E. H. B.

1061. *Latent Heat of Steam.* **F. Henning.** (Ann. d. Physik, 58. 8. pp. 759–760, May 27, 1919. From the Physikal.-Techn. Reichsanstalt.)—The values for the specific heat of water from 5° to 50° published by Jaeger and v. Steinwehr [see Abs. 209 (1916)] do not produce any modification of the author's value for the latent heat of steam [Abs. 1418 (1909)]. J. W. T. W.

1062. *Thermal Expansion of Crystals.* **E. Grüneisen.** (Ann. d. Physik, 58. 8. pp. 753–758, May 27, 1919.)—A mathematical discussion of the author's previous work and Debye's expansion law. [See Abs. 1105 (1918).]

E. H. B.

1063. *Some Experimental Proofs of Debye's Theory of Heat Conduction in Crystals.* **F. A. Giacomini.** (Deutsch. Phys. Gesell., Verh. 20. pp. 94–96, June 30, 1918.)—Gives experimental results which show good agreement with the theoretical values due to Debye's formula. [See Abs. 693 (1914).]

E. H. B.

1064. *Specific Heat of Hydrogen.* **P. S. Epstein.** (Deutsch. Phys. Gesell., Verh. 18. pp. 398–413, Dec. 15, 1916.)—Mathematical treatment of the subject on the quantum theory. [See Abs. 1016 and 1445 (1913).]

E. H. B.

1065. *Specific Heat of Mercury. Heat Content of Metallic Liquids at the Melting-point and its Relation to Specific Heat, Electrical Conductivity, and Viscosity.* **F. Skaupy.** (Deutsch. Phys. Gesell., Verh. 18. pp. 302–307, June 30, 1916.)—Mathematical treatment. E. H. B.

1066. *Radiometer.* **W. H. Westphal.** (Deutsch. Phys. Gesell., Verh. 21. pp. 129–143, April 30, 1919.)—A mathematical treatment of the theory of the radiometer. A formula is first deduced for the surface temperature of plates of one or of two different layers, upon which radiant energy falls. A second formula is then derived for the radiometer pressure for gas pressures such that the free path of the molecules is small compared with the dimensions of the apparatus. This formula is, apart from discrepancy at higher pressures, in qualitative agreement with experiment. In particular, it affords an explanation of the movement of a radiometer towards the incident radiation, as observed by Gerlach and the author. [See also Abs. 1180 (1910).] A. W.

1067. *Monochromatic and Neutral Tint Screens in Optical Pyrometry.* **W. E. Forsythe.** (Astrophys. J. 49. pp. 237–248, May, 1919.)—Shows that with a good red glass in the eyepiece of a pyrometer, absorbing glasses can be found that are near enough to being of neutral tint for different observers to obtain the same values of measured temperatures. Absolutely monochromatic screens have the disadvantage that they do not transmit enough light to permit of accurate comparisons of brightness at low temperatures. J. W. T. W.

1068. *The Principles of and Methods employed in Pyrometry.* **F. Henning.** (Phys. Zeits. 20. pp. 34–47, Jan. 15, 1919.)—Forms a compact treatise dealing with present-day methods. L. H. W.

1069. *Vapour Tensions of Metals.* **J. W. Richards.** (Frank. Inst., J. 187. pp. 581–598, May, 1919.)—A discussion of various formulæ representing the relation between temperature and vapour tension of the metals. For all ordinary purposes the straight-line formula, $\log p = -A/T + B$, where A and B are constants, is satisfactory. Differentiation of this equation gives $dp/dT = A/mT^2$, and if this is combined with the Clapeyron-Clausius equation, $L = RT^2 dp/dT$, it follows that $L = RA/m \; 4{\cdot}57\,A$ (R is the gas constant and m the logarithm modulus, 0·4248). In this way the constant A is connected with the latent heat of vaporisation. Richards has previously shown that the molecular latent heat of fusion of a solid is approximately 2·1 T, where T is the absolute melting-point, and this relation can be used in deriving the straight-line relation for the sublimation of a solid metal below its melting-point. The relation is $\log p = A'/T + B'$ (the $'$ denotes the solid), and in this equation $4{\cdot}57\,A'$ is the latent heat of sublimation. The latent heat of sublimation equals, however, the sum of the latent heat of vaporisation of the liquid and the latent heat of fusion, so that $4{\cdot}57\,A' = 4{\cdot}57\,A + L$ (fusion). Also, by making use of the condition that at the melting-point the vapour tensions of the solid and liquid are equal, it can be shown that $B' = B + L(\text{fusion})/4{\cdot}57\,T_{\text{m.pt.}}$. Thus if the latent heat of fusion is known both A′ and B′ can be calculated and hence the complete vapour tension line for the *solid* state. If the latent heat of fusion is not known it may be put, as a first approximation, as equal to $2{\cdot}1\,T_{\text{m.pt.}}$. It follows that $A' = A + 0{\cdot}46\,T_{\text{m.pt.}}$, and $B' = B + 0{\cdot}46$.

In the case of arsenic, taking experimental values, it is found that $A' = A + 0{\cdot}45T_{\text{m.pt.}}$, and $B' = B + 0{\cdot}45$, values in good agreement with the theoretical.

From the above discussion it follows that given two determinations of vapour tension and temperature a straight-line relation can be found between them; if this is for the liquid state a similar equation for the solid state can be deduced if the melting-point and latent heat of fusion are known, and *vice versa*. If only one such determination is known, either for the solid or liquid, B or B′ can be assumed and then A or A′ calculated, and thence the whole of both equations. If the latent heat of fusion is not known it may be assumed equal to $2{\cdot}1T_{m.pt.}$, and then the complete scheme worked out. Finally, if there are no data for the vapour tension, but the latent heat of vaporisation (of the liquid) or the latent heat of sublimation (of the solid) is known, a vapour tension equation for the solid or liquid state can be worked out as a first approximation; if the melting-point is known one equation can be deduced from the other. Using the above principles the author has calculated the vapour tensions of the metals, and some non-metals, in the solid and liquid states, at their melting-points and at 0° C. The non-metals are H, Br, I, P, S, As, Se, Si, B and C. A table is also given of the latent heats of vaporisation, as calculated by Trouton's rule: the experimental values are also given when known. The results obtained are discussed in connection with the following practical applications: Distillation of metals; zinc losses in brass melting; loss of metals as fume; Sherardising and Calorising; vapour losses during electrolysis of fused salts. T. S. P.

1070. *On the Quanta Theory for the Heat of Rotation of Hydrogen.* **F. Reiche.** (Ann. d. Physik, 58. 8. pp. 657–694, May 27, 1919.)—The experiments of Eucken have shown that the heat of rotation of gaseous hydrogen (namely, that part of its molecular heat which proceeds from the two rotation degrees of freedom of the molecule), does not possess for all temperatures the value $R = 1{\cdot}985$ cals. as given by the classical theory, but sinks gradually towards zero at low temperatures. This decline in the heat of rotation of diatomic gases was treated theoretically from the quanta standpoint by Nernst, and later, although not entirely free from defect, by Einstein and Stern [see Abs. 1016 (1918)] and many others. The present author commences by classifying previous investigations according to their various standpoints, namely: Molecular Models, Number of Degrees of Freedom, or whether based on the first or second of Planck's quanta theories. The present investigation treats the problem generally as one of two degrees of freedom, and as an extension of Ehrenfest's calculations. Hereby curves are obtained for the heat of rotation of hydrogen which can be compared with those calculated by Planck and Rotszayn from the second theory of Planck. Section 1 of the paper discusses methods for the solution of the problem. These consist of two parts, namely, dynamic and statistical. In the former the quanta motions of the hydrogen molecule, *i.e.*, of a Hantel model, are investigated, these giving, on the first Planck theory, the only possible states of the molecule. In the statistical part, a system of a large number of homogeneous molecules in thermodynamic equilibrium at a given temperature is investigated, the distribution of the energy of rotation in this system being determined and thence the average energy of rotation of the whole system calculated. By differentiation according to the temperature, the heat of rotation is obtained as a function of the temperature. Two methods of solution are considered: section 2 deals with the first, which regards both atoms of the molecule as provided with equal and opposite magnetic charges, *i.e.*, a magnetic dipole, and placed in a constant homogeneous weak magnetic field; section 3 deals with the second, which starts from the problem of the heavy symmetrical top, with two equal moments of inertia perpendicular to the axis and a different one about it, in the gravitational field. Section 4 considers the statistical part of the problem and the solution. Sections 5 and 6 deal with the cases where the nth quanta state has the weights $2n+1$ and $n+1$ respectively. In sections 7 and 8 it is shown that the zero quanta state for curves I and II is excluded, and in section 9 that the same applies when $n_2 = 0$. Section 10 discusses Planck's curve. Section 11 summarises the curve results, while an appendix deals with two-dimensional and three-dimensional quasi-elastic oscillators. H. H. Ho.

1071. *The Entropy Equation for Solid Bodies and Gases and the Universal Quantum-effect.* **S. Ratnowsky.** (Deutsch. Phys. Gesell., Verh. 18. pp. 263–277, May 30, 1916.)—According to the latest researches it appears as if Planck's fundamental assumption, that the energy can only be distributed in finite quanta, corresponds best to the observed facts. In this connection the work of Bahr [Abs. 1946 (1913)] is quoted, in which the non-homogeneity of the absorption bands of gases in the ultra-red was shown, and also the theoretical investigations of Bjerrum on the same subject. Similarly may be quoted the work of Franck and Hertz, showing that the electrons are reflected at mercury atoms without loss of energy for the case where the kinetic energy of the former is less than a definite energy-quantum $h\nu$, and that a transference of energy takes place on impact at the atom as soon as the kinetic energy of the electron exceeds the amount $h\nu$. This last result affords very important evidence for the discontinuity of energy and so for the support of Planck's hypothesis. In the present paper it is shown that the assumption of a system of material structures forming an energy reservoir with absence of thermal energy from which the structures receive energy direct as from an energy source external to the system, suffices in order to obtain, on the basis of Gibbs's statistical mechanics, the expressions for entropy and energy in agreement with those deduced from the quanta standpoint. It follows from the above assumption, that the relation between the characteristic limiting value ϵ_0 for the system of the special energy of a degree of freedom and the oscillation frequency ν of the structure is a universal constant ($\epsilon_0 = h\nu$), which brings about complete agreement for the entropy and energy expressions with those of quanta theory. Also the general entropy equation for gases as deduced by Tetrode under the assumption that the entropy of the solid body is given by the Planck equation, is given by the present method without any recourse to the quanta hypothesis. It is therefore possible by entirely different means to obtain the formula for the vapour pressure of solid bodies and the entropy constant of gases. H. H. Ho.

1072. *Radiation Constants c_2 and σ.* **F. Henning.** (Deutsch. Phys. Gesell., Verh. 20. pp. 81–85, June 30, 1918.)—From the direct radiation measurements the following values are obtained: $c_2 = 1{\cdot}43 \pm 0{\cdot}01$ cm. degree; $\sigma = (5{\cdot}67 \pm 0{\cdot}18) \times 10^{-5}$ erg. cm.$^{-2}$ sec.$^{-1}$ degree^{-4}. From Sommerfeld's theory, the measures of spectral lines and the value for the electron charge, are obtained: $c_2 = 1{\cdot}432 \pm 0{\cdot}005$ cm. degree; $\sigma = (5{\cdot}717 \pm 0{\cdot}052) \times 10^{-5}$ erg. cm.$^{-2}$ sec.$^{-1}$ degree^{-4}. [See Abs. 48 (1917).] E. H. B.

1073. *Direct Determination of the Temperature Exponent in the Equation of State for a Fluid.* **E. Ariès.** (Comptes Rendus, 168. pp. 930–933, May 12, 1919.)—The formula, $\nu_1 - \nu_2 = (RT_c/8P_c)(x/r^{n+1})(y_1 - y_2)$, where ν_1 and ν_2 refer to the molecular volumes of a saturated fluid as vapour or liquid, has already been applied to 7 different substances—namely, stannic chloride, methyl formate, ethyl formate, propyl formate, propyl acetate, hexane, and heptane—for the direct determination of the exponent n. Here the number of atoms increases by 3 in passing from one to another along the series, and the values of n range from 1·05 to 1·80. A table is given to show how closely the variations of $\nu_1 - \nu_2$ with temperature as given experimentally agree with those calculated from the formula. The greatest deviations always occur for the high temperatures and especially in the neighbourhood of the critical temperature, although it is necessary to remember that measurements become more and more difficult as the critical state is approached. A short discussion is given from which it is concluded that for all bodies the curve having the reduced temperature τ as abscissæ and the corresponding values of Γ as ordinates, should present at the critical point ($\tau = 1$, $\Gamma = 1$) a tangent parallel to the τ axis. The differential of the function should be zero for $\tau = 1$. H. H. Ho.

1074. *Application of the Gibbs-Helmholtz Equation $A - U = T(\partial A/\partial T)$ to Monovariant Systems.* **A. Boutaric.** (Comptes Rendus, 168. pp. 989–942, May 12, 1919.)—The equation of Gibbs-Helmholtz, $A - U = T(\partial A/\partial T)$ in which A represents the max. work furnished by an isothermal process at temperature T, and U the corresponding diminution in the total energy of the system, has been established for thermo-elastic systems whose state depends at least on two independent variables v and T. For such systems, the variation U of the total energy may be calculated without ambiguity as a function of v and T when the variation A of the free energy is known as a function of the same variables. Similarly when U is known A may be determined. When transformations of monovariant systems are considered, the volumes which occur being determined by the temperature, then A and U become single functions of T. At first sight, therefore, it would seem that the Gibbs-Helmholtz equation should be replaced by $A - U = T\,.\,dA/dT$, where dA/dT is the differential with respect to T of A as a function of the single variable T. This assumption is made implicitly by Nernst and all his collaborators in the application they make of the Gibbs-Helmholtz equation for the calculation of A from thermal data alone as furnished by the function $U = f(T)$. The author now shows that such an extension is invalid, at least for the general case, and would lead to gross error. As an illustrative example he takes the case of vaporisation of a solid or of a liquid, and shows that an inexact expression for the heat of vaporisation results. The author next modifies the equation in such a manner as to render it applicable to isothermal transformations of monovariant systems. If dv represents the volume variation of one of the phases under a pressure p, where p and v are functions of the temperature alone, the modified equation becomes $A - U = T(dA/dT - \int p\,.\,d^2v/dT^2\,.\,dT)$, and may be applied to the fusion of a solid in presence of the liquid and under the corresponding equilibrium pressure only. H. H. Ho.

SOUND.

1075. *Listening under Water.* **W. H. Bragg.** (Engineering, 107. pp. 776–779, June 13, 1919. Tyndall Lectures delivered before the Roy. Inst., May and June, 1919.)—How efficiently water carries sound has long been known. In their first experiments, in 1826, Collodon and Sturm heard their bell, immersed in the water, right across the Lake of Geneva. Down in the hull of a ship, one might hear that somebody was dropping a shovel in a passing ship. The bell signals of the Electric Signalling Co. can be picked up at distances of seven miles and more. But listening to a sound that is produced to be heard, is a different thing to listening to the unavoidable noise made by a boat that wishes to pass unnoticed. The extremely perilous hunt of the Navy for submarines would have been facilitated if they had had some means of knowing when they were within a mile of a submarine. Acoustics has really rendered valuable aid in that hunt, but it has taken long to bring the method to a satisfactory state.

The second lecture dealt with the determination of the direction of the arriving sound. For this purpose an instrument like a microphone was used with and without baffles. But for the details of these, so far as given, the paper itself and its diagrams should be consulted, as the intricacy renders abstraction difficult. E. H. B.

1076. *Electrically-driven Tuning-forks.* **H. M. Dadourian.** (Phys. Rev. 13. pp. 337–359, May, 1919.)—Records a series of experiments performed to determine the conditions affecting the period of an electrically-operated tuning-fork. The chief results are as follows:—(1) The more massive the base of the fork and the table upon which it is placed, the smaller the period. This effect does not exceed 1 in 10,000. (2) A change in the constants of the electrical circuit affects the period. But this effect is less than 1 in 10,000 for moderate changes needed to keep the amplitude of vibration constant. (3) The period increases linearly with the increase in the length of the gaps between the contact springs and points. For the forks used this increase was about 1 in 500 for a change of 1/10 mm. in the gaps. (4) For a given fork there is an amplitude at which the period has a stationary value. This may be a maximum or a minimum, depending upon the arrangement of the mounting of the contact springs. (5) The temperature effect increases from $1{\cdot}04 \times 10^{-4}$ at $-25°$ C. to $1{\cdot}48 \times 10^{-4}$ at 56° C. (6) By keeping the temperature, the length of the gap, and the amplitude constant, a well-made fork can be relied upon for a frequency accurate to 1 in 50,000. (7) The theoretical expression for the period of a bar holds good for a tuning-fork. (8) The velocity of sound in the steel used is $5{\cdot}49 \times 10^5$ cm. per sec. (9) The elastic modulus for the steel is $19{\cdot}10 \times 10^{11}$. E. H. B.

1077. *Apparatus for Absolute Acoustic Measurements.* **A. G. Webster.** (Nat. Acad. Sci., Proc. 5. pp. 173–179, May, 1919. Am. I. E. E. Proc. 38. pp. 889–900, July, 1919.)—Describes with elaborate diagrams and perspective views the author's *phone,* for giving a simple tone of known intensity, and the *phonometer,* for measuring in absolute units a constantly-maintained simple tone. [See Abs. 655 (1917) and 769 (1919).] E. H. B.

1078. *Sound Sources and Receivers.* **W. Hahnemann and H. Hecht.** (Phys. Zeits. 20. pp. 104–114, March 1, and pp. 245–251, June 1, 1919.)—A mathematical discussion of telephones, transformers, etc. [See Abs. 1294 (1917) and 778 (1919).] E. H. B.

1079. *Theory of Combination Tones.* **E. Budde.** (Deutsch. Phys. Gesell., Verh. 21. pp. 70–84, March 30, 1919.)—A critical survey of the various theories that have been advanced. [See Abs. 1428 (1909).] E. H. B.

1080. *D'Alembert's Theory of Vibrations of Strings.* **E. Budde.** (Deutsch. Phys. Gesell., Verh. 21. 5 and 6. pp. 100–109, March 30, 1919.)—A brief survey of classical treatments of the problems involved. E. H. B.

1081. *Flutes and Whistles.* **R. Dunstan.** (Phys. Soc., Proc. 31. p. 229 with Discussion, June, 1919.)—Experiments showed that cylindrical flutes appear to require an end connection which—within certain limits—is equal to D^2/d, where D is the diam. of the pipe and d the mean diam. of the mouth hole. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1082. *Alleged Gravitational Attraction between Revolving Electrons.* **A. C. Crehore.** (Phys. Rev. 13. pp. 89–95, Feb., 1919.)—The author, as a preliminary reply to G. A. Schott's criticisms [Abs. 14 (1919)] prior to a full inquiry into the question of averaging, states that the magnetic component had been obtained and averaged like the electric component, but not published because the final average was affected by a common factor in powers of β higher than the square, and takes exception to Schott's conclusion regarding the forces between distant bodies, claiming that Schott's formula would merely reduce its ratio to the known gravitation force, assuming β of order 10^{-4}, from 10^{31} to about 10^{27}, which would not affect the author's argument. G. W. de T.

1083. *Decomposition of Liquid Dielectrics by the Electric Arc.* **E. Urbain** and **C. Scal.** (Comptes Rendus, 168. pp. 887–889, May 5, 1919.)—Dielectrics like oils and the tetrachlorides of carbon, tin, titanium require a high potential for their breakdown by currents passing through them, but the arc can subsequently be maintained by a much lower potential. Studying these phenomena with the aid of a Tesla transformer the authors find that the rupture liberates little gas, but that the arc yields an abundant gas evolution; the liquid has to be kept cold lest the reactions become violent. The tetrachlorides yield chlorine; saturated hydrocarbons give acetylene, ethylene, and hydrogen, and sooty carbon is deposited; pinene yields the same products and in addition oprene; ketones yield carbon monoxide and various hydrocarbons. The potentials used are much lower than those applied by Grignard (10,000 volts) in recent experiments at Pittsburg, a few thousand volts reduced to 500 or 110 volts in the arcs. Metallic electrodes should be provided, because between carbon electrodes short-circuits of carbon are formed. H. B.

DISCHARGE AND OSCILLATIONS.

1084. *Conductivity and Absorption of Sodium Vapour.* **A. Campetti.** (N. Cimento, 16. ii. pp. 115–138, 1918.)—The results of the author's experiments show that, in unsaturated sodium vapour kept in the dark and freed from electrons emitted from the surface of the fused metal, spontaneous ionisation in the volume of the vapour occurs at high temperature; this ionisation becomes clearly manifest above 400° without marked dissymmetry as regards the sign of the disperse charge. Such conductivity in the volume of the vapour is closely connected with the commencement of the absorption of the D-line, which under the above conditions is observed only at about 430°, but then persists when the temperature falls considerably. The cause of the appearance of absorption at somewhat lower temperatures under the ordinary conditions of observation is clearly shown to be the presence of electrons either given off from the surface of the molten metal or arising from the atoms of the metal in the state of vapour as a result of photoelectric action. It appears probable that the emitting or absorbing vibrators in sodium vapour are, for the D-line, the positive atom ions. T. H. P.

1085. *Energy Loss due to Electron Emission from an Incandescent Tungsten Filament.* **M. Sô.** (Phys.-Math. Soc. Japan, Proc. 1. pp. 122–128, May, 1919.)—Calculation of the energy loss due to electron emission from an incandescent tungsten filament shows that if the whole thermionic emission from a filament at a temperature of 2400° K. were stopped, the resultant rise of temperature would only be 0·3 deg. Consequently no appreciable increase in efficiency of the tungsten lamp could be obtained by stopping the electron emission from the filament. A. W.

1086. *The Passage of Photo-Electrons through Metals.* **K. T. Compton** and **L. W. Ross.** (Phys. Rev. 13. pp. 374–391, May, 1919.)—Theoretical expressions are derived giving the rate of escape of photo-electrons from the surface of a thin metallic film as a function of its thickness. These expressions result from various assumptions regarding the probability of escape of an electron photo-electrically excited at a given depth within the metal.

The photo-electric currents from films of Pt and of Au of various thicknesses are measured for different wave-lengths of light, and the results are found to be consistent with the view that the average distance in any direction which an excited electron may move without losing its ability to escape is about $2{\cdot}67 \times 10^{-7}$ cm. in platinum and $5{\cdot}0 \times 10^{-7}$ cm. in gold, and that the probability of going a given distance without losing its ability to escape falls off exponentially with the distance. This average distance is shown to be independent of the initial kinetic energy of the electron. There is evidence that Pt is first deposited in a relatively unstable and electro-positive state, and that it spontaneously changes into the ordinary stable form.

A critical discussion and comparison of methods of measuring film thicknesses shows that they may be relied upon if proper precautions are taken. Various interesting properties of these thin films are illustrated and discussed. AUTHORS.

1087. *Field Strength and Separation of Hydrogen Lines in front of Kathode.* **E. Brose.** (Ann. d. Physik, 58. 8. pp. 731–752, May 27, 1919.)—A discussion of (1) the probe method, and (2) the method involving the use of kathode rays, of determining the special distribution of potential in front of the kathode in a discharge tube, shows that both are open to objection. Stark's results on the separation of the hydrogen lines in strong fields were accordingly used to determine the kathode fall of potential in a number of hydrogen discharge tubes, the line H_γ being selected for observation. All the discharge tubes employed were cylindrical, and both anode and kathode were made of aluminium. The tubes were kept cool during the experiments by means of water. The results for different tube diameters and different lengths of the dark space are tabulated and graphed. They show that in the immediate neighbourhood of the kathode the field strength has a large value, which increases to a maximum at a little distance from the kathode and then falls away gradually to a very small value towards the negative glow. The distance from the kathode of the max. field strength, for the same tube, alters only a little with increased pressure. The distance is from 0·1 to 0·5 mm., the smaller values being found with tubes of small diam. and with small kathode dark space. With a large dark space the field strength falls off almost linearly with distance from the kathode, but with small values for the length of the dark space the field strength falls off at first quickly and then less quickly towards the negative glow. The results show that there is always just in front of the kathode a layer having a negative charge. The space charge becomes zero when the field strength has a max. value, and from this point up to the negative glow the dark space is positively charged. The positive charge rises rapidly to a max. value and then falls gradually to a very small value. A. W.

1088. *Theory of Space-charge Effects.* **P. S. Epstein.** (Deutsch. Phys. Gesell., Verh. 21. pp. 85–99, March 30, 1919.)—A mathematical treatment of the space-charge effects in a vacuum with a glowing kathode between two infinite plane electrodes. [See Abs. 1588 (1914).] A. W.

1089. *Electrical Changes produced by Light.* **H. S. Allen.** (Röntgen Soc., J. 15. pp. 33–41; Disc., 41–44, April, 1919.)

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1090. *Conductivity of Sea-water for Currents of Frequencies as used in Wireless Telegraphy.* **B. van der Pol, Jr.** (Phil. Mag. 36. pp. 88–94, July, 1918. Electrician, 81. p. 432, Sept. 20, 1918. Abstract.)—Using a substitution method, the author has measured the conductivity of a sample of sea-water from Hastings. The h.f. currents were obtained from a triode valve generator.

It is found that the conductivity for all frequencies as used in wireless telegraphy is very nearly equal to the value of the same for steady currents to within less than 0·5%. Such small differences as were noted were probably due to a small capacity effect of parts of the shunt on other parts. L. H. W.

1091. *Thermoelectric Properties of Certain Polymorphous Metals.* **P. N. Laschtschenko, S. F. Bykov, and S. V. Efremov.** (Russian Phys.-Chem. Soc., J. 48. pp. 279–296, 1916.)—Measurements have been made at different temperatures of the thermo-potentials of a number of pairs of metals, one metal in each case being capable of existing in polymorphous modifications; the numerical results are given, and also the curves showing the connection between e.m.f. and temperature.

The nickel-platinum curve shows a characteristic bend in its early part, but no break, and the temperature-coefficient of the thermoelectric force ($\partial E/\partial t$) exhibits a minimum at about 400°. With iron-platinum, $\partial E/\partial t$ has minima at 475° and 1025°, and a maximum at 850°, the last temperature corresponding nearly with the transformation of β- into γ-iron [compare Broniewski, Abs. 1542 (1913).]

With Zn-Pt, Zn-Pd, Zn-Au, and Zn-Fe, the results obtained bear little relation to allotropic change of the zinc. With zinc-copper, however, this change is sharply shown, the neutral point, at which the thermo e.m.f. is a maximum, being at about 240°; at 310°, the curve again assumes its regular parabolic form, this temperature being regarded as that of the transformation of the zinc. The Sn-Pt curve shows no peculiarity, but the Sn-Ni curve consists of two branches meeting at a very slight angle at 160°–165° [compare Degens, Abs. 1782 (1909); Werner, Abs. 2025 (1914)]. The influence of the allotropy of thallium on the thermoelectric properties of the metal appears, from a study of Tl-Pt, Tl-Cu, and Tl-Ni, to be only slight (compare Werner, *loc. cit.*).

Investigation has been made of aluminium paired with Pt, Pd, Ag, and constantan, the Al employed containing 1·30%Si, 0·85%Fe, and traces of copper. In all these cases, the curves exhibit changes in direction at temperatures lying within the limits 570°–590°, which are in agreement with those observed by other investigators in other ways. T. H. P.

1092. *Simplified Inductance Calculations, with Special Reference to Thick Coils.* **P. R. Coursey.** (Phys. Soc., Proc. 31. pp. 155–166; Disc., 167, June, 1919.)—The method of calculation advocated in the paper is based on an extension of Nagaoka's formula for single-layer coils, to include as well all ordinary forms of thick coils. Rosa's formula for thick coils is put into the same form as Nagaoka's, and its use enables a series of correction factors to be calculated for various coil thicknesses. By the aid of a single sheet of curves giving values of these correction factors the inductance of any form of coil likely to be met with in practice may be readily calculated, using only one simple standard formula for all cases. Reasonable accuracy is obtained even in the limiting example of a single turn of wire. The results arrived at agree well with other published charts, which are usually of more limited application, while the use of a single formula lessens the liability to error.

It is also shown that Rayleigh and Niven's formula enables the calculation of the correction factors for very short coils to be carried out without having recourse to Nagoaka's more complicated expressions. AUTHOR.

1093. *Silver Voltameter.* **J. Obata.** (Electrotechn. Researches Lab. Tōkyō, No. 76. pp. 1–21, May, 1919.)—The Richards or porous cup form of voltameter, using the least permeable porous cup as the septum, was compared with the Smith form. It is concluded that the latter gives a heavier deposit by about 2 parts in 100,000, a difference which is attributed to the effect of the anode liquid and not to electro-stenolysis. During electrolysis the acidity of the electrolyte was always found to increase in the Richards' form, whereas in the Smith form it remained constant. A voltameter containing 2 porous cups, a small one inside a larger one, was set up, and as this did not give a lighter deposit than one with a single porous cup, the author concludes that electro-stenolysis has no measurable effect. [See Abs. 568 (1918).] F. E. S.

1094. *The "Electric Egg" with Accessible Inner Cavity.* **W. B. v. Czudnochowski.** (Deutsch. Phys. Gesell., Verh. 20. pp. 97–98, June 30, 1918.)—The usual form of apparatus which is known as the "Electric Egg" is so constructed as to be very limited in application. The present modification is so arranged that these limitations are removed. A diagram showing the new form of tube is given. The more important problems which it is claimed this tube can be used to investigate are: The vacuum discharge in air; magnetic influence on the vacuum discharge; electrostatic deviation; electromagnetic induction *in vacuo*; electrostatic induction; light appearances in a vacuum through induction by means of electric oscillations. A. E. G.

1095. *Navigational Magnetic Compass.* **M. B. Field.** (Inst. El. Eng., J. 57. pp. 349–386, May, 1919. Engineering, 107. pp. 187–192, Feb. 7, 1919. Abstracts in El. Rev. 84. pp. 66–67, Jan. 17; 110–112, Jan. 24, and p. 122, Jan. 31, 1919. Electrician, 82. pp. 148–150, Jan. 31, 1919.)—The navigational magnetic compass is in this paper considered as an instrument of precision. After a brief discussion of the Kelvin compass, the liquid or spirit compass is considered. Subsequent sections deal with (1) Distribution of the magnetism of a compass needle, and the Smith-Evans 60° system; (2) Compensation for the ship's magnetism by the introduction of auxiliary magnetic fields; (3) Magnetic field in the region of the quadrantal correctors; (4) Testing of compasses. Methods and apparatus for measuring (*a*) the magnetic moment, (*b*) magnetic distribution, (*c*) the sextantal and octantal effects, (*d*) the effect of magnetic dissymetry of the card. The original paper should be consulted by those interested, as a brief abstract cannot be given. A. W.

ALTERNATING CURRENTS AND MAGNETISM.

1096. *Magnetic Properties of Cubic Lattices.* **L. S. Ornstein** and **F. Zernike.** (K. Akad. Amsterdam, Proc. 21. 6 and 7. pp. 911–921, 1919.)—The Ewing model has been dealt with, among others, by Honda and Okuba [Abs. 411 (1918)] assuming magnetic particles arranged in a cubic lattice. They, however, neglected the demagnetising force and replaced the doublets by magnets of finite length. The axes of all moved in mutual parallelism. With this limitation to the freedom of motion the stability is much greater than is really the case. If this limitation is rejected, the arranging of magnetic atoms in a cubic lattice is unstable without external field. A body of such a structure possesses no coercive force. The authors treat mathematically the case of doublets arranged at the corners of a cubic lattice. They can rotate freely and are directed parallel to the edge of the lattice by an external field. The coercive force is found to be one-third of the magnetisation of saturation. Actually for steel the coercive force is 80 times smaller. The same result holds for the centred cubic and the plane-centred cubic lattice. The magnetic properties are represented by discontinuous lines. Rounding off of these lines is probably due to thermal vibrations and to the fact that real materials are aggregates of crystals lying at random in all directions. L. L.

1097. *Susceptibility of feebly Magnetic Materials.* **E. Wilson.** (Inst. El. Eng., J. 57. pp. 416–417, May, 1919. Address delivered to Students' Section.)—The method of determining the susceptibility by measuring the force on the specimen when placed in a non-uniform magnetic field is outlined and a table of volume susceptibilities for a number of materials is given. The magnitude of the susceptibility must not be pre-judged from the standpoint of the iron content. A knowledge of the susceptibility of feebly magnetic substances has assumed importance in magnetic survey work and in problems which deal with the magnetic separation of ores. L. L.

1098. *Significance of the Magnetic Susceptibility of Solutions. Nuclear State of Solutions.* I. **A. Quartaroli.** (Soc. Chim. Ital., Gazzetta, 48. i. pp. 79–101, 1918.)—Further evidence is advanced [compare Abs. 724 (1916)] confirmatory of the view that support for Weiss's magneton theory cannot be obtained from data regarding dissolved salts. By means of the differential method devised for the estimation of magnetic salts in solution [Abs. 738 (1916)], and making use of a solution of nickel chloride, carefully freed from cobalt, as standard solution, the author has measured the magnetic susceptibilities of various ferric, ferrous, manganese, cobalt, chromium, and copper salts at different dilutions. The results show that, on the assumption that that of nickel chloride remains constant, in general the molecular susceptibility decreases slowly with increase of the dilution; it is, however, impossible by extrapolation to calculate a limit, since the diminution appears to become rather more rapid as dilution progresses. This holds true even if, as is probably the case, the molecular susceptibility of nickel chloride itself undergoes some diminution on dilution. The differential method referred to also allows of the alteration of the susceptibility by centrifugation being detected in solutions containing 1 part of ferric or manganese chloride or sulphate in 5000 parts of water, or 1 part of nickel chloride or sulphate per 1000 parts of water.

From the results obtained, the conclusion is drawn that there exists a discontinuity in the relation connecting the variation in concentration with the force tending to oppose such variation, an almost infinitesimal change of concentration counterbalancing appreciable definite forces acting to increase the change. It is suggested that the state of solution represents a special "nuclear" condition, in which, although the characteristic external attributes of liquids are not lost, attractions emanating from the centre of the nuclei (molecules of solute) determine regions of greater rigidity.

The explanation of various phenomena by means of this hypothesis is discussed. T. H. P.

1099. *Magneto-Chemistry. Applications to Analytical Chemistry.* II. **A. Quartaroli.** (Soc. Chim. Ital., Gazzetta, 48. i. pp. 65–78, 1918.)—The method previously devised [Abs. 724 (1916)] for the estimation of magnetic salts in solution by measuring the magnetic susceptibility may be replaced by the procedure described below, which may be used with magnetic fields of moderate intensity and requires no special apparatus. By means of truncated conical poles with circular faces, a field is obtained in which a zone of great intensity is separated sharply from one of feeble intensity. The solution to be examined is introduced into a small tube of about 8 mm. internal diam., and above it is placed, carefully and without mixing, coloured water. The tube is then arranged so that the surface of separation of the two liquids corresponds with the lower point where the poles begin to diverge. When the magnet is excited, the water bulges out into the magnetic solution beneath without sensibly mixing with it, and if the field is sufficiently intense and the susceptibility of the solution great enough, a globule of the water becomes detached and remains suspended in the magnetic liquid. The phenomenon is visible with weak fields and dilute solutions which yield scarcely perceptible indications by Plücker's or the U-tube method. Naturally, the results become more marked as the specific gravities of the two liquids approach equality.

In the application of this phenomenon to quantitative analysis, a standard solution of ferric chloride containing a little hydrochloric acid is placed in the lower part of the tube, and the solution of the ferric salt to be analysed carefully pipetted on to the top of this solution; the upper liquid is then gradually diluted with successive diminishing quantities of water until only a just perceptible bulge slowly appears; the magnet should be excited for at least a minute, and the disappearance of the phenomenon when the current is interrupted employed as a control. The results thus obtained with ferric chloride solutions of the respective concentrations 0·519, 0·2076, 0·0798, 0·0822, 0·0129, and 0·00515 % were 0·5176, 0·2070, 0·794, 0·0818, 0·0126, and 0·00500 % with a field of 12,000 gauss, and 0·5181, 0·2078, 0·0795, 0·0820, 0·0127, and 0·00504 % with a field of 30,000 gauss; in the latter case, a 0·002 % solution gave the value 0·00184 %.

As the magnetic susceptibility of ferric sulphate is, for certain concentrations, rather higher than that of the chloride, the sulphate ion should be removed by precipitation with barium chloride, followed by either filtration or decantation. The actual determination then occupies usually about fifteen minutes, and at most 2 cm.^{3} of the liquid are necessary. The surface of separation is often visible owing to variation in the refraction, but it is convenient to add one of the ordinary indicators to the water used for dilution. The determination of iron in this way is not affected by the presence in the solution of aluminium, phosphoric acid, etc., but if manganese or chromium salts are present, modification is necessary.

For further details the original should be consulted. T. H. P.

1100. *The Calorimetry and Specific Heat of Magnetic Substances.* **P. Weiss, A. Picard, and A. Carrard.** (Archives des Sciences, 42. pp. 378–401, Nov., 1916, and 43. pp. 22–52, Jan., and pp. 199–216, March, 1917.)—The object of this research was the revision of the work of Weiss and Beck [Abs. 1496 (1908)]. The first part of this paper deals with the construction and calibration of the electric-resistance thermometer used in the research, and with the calorimetric methods employed; the second part describes the measurement methods used in the specific-heat determinations and gives the results. The substances investigated were (1) a nickel supplied by the Mond Nickel Co., (2) artificial magnetite, (3) natural magnetite, (4) silver, (5) electrolytic iron (gold-coated), (6) Swedish iron. The mean specific heats are obtained from the calorimetric tests; the specimens being heated up in an electric furnace. From these results the true specific heats (*i.e.*, the mean specific heat *plus* the magnetic term, *loc. cit.*) are obtained by the method of tangents.

Nickel.—The authors find for the discontinuity ΔC of the true specific heat and for the temperature θ at which it occurs:

$$\Delta C = 0{\cdot}285 \qquad \theta = 363^\circ + 273^\circ.$$

These results agree satisfactorily with those obtained previously and with those of Weiss and Beck and Weiss and Piccard. From Lorentz's formula, assuming that the molecule is Ni_3, the value $\Delta C = 0{\cdot}0282$ is obtained. This is the more curious in that in the magnetic measurements nothing suggests such a polymerisation.

Magnetite.—The two sorts examined gave:

$$\Delta C = 0{\cdot}0790 \qquad \theta = 593{\cdot}5^\circ + 273^\circ \text{ (artificial)}$$
$$\Delta C = 0{\cdot}0785 \qquad \theta = 585^\circ + 273^\circ \text{ (natural)}$$

The results of Weiss and Beck were lower: reasons for this are given. If, on the molecular field theory applied above the Curie point, the magnetic molecule is assumed to be $\frac{1}{3}(Fe_3O_4)$, that is, each iron atom is the carrier of a magnet of independent orientation, the value found for ΔC is 0·0644. This figure is lower than the lowest of the author's calorimetric values for natural magnetite.

Iron.—The present experiments give:

$$\Delta C = 0{\cdot}120 \qquad \theta = 784^\circ + 273^\circ \text{ (pure iron)}$$
$$\Delta C = 0{\cdot}124 \qquad \theta = 784^\circ + 273^\circ \text{ (Swedish iron)}$$

These ΔC values agree well with those of Weiss and Beck, but the values for θ are higher than those found by other workers. The authors' measurements tend to show that the calorimetric and magnetic θ-temperatures are identical. If the molecule of iron is assumed as being the atom itself, Lorentz's formula gives $\Delta C = 0{\cdot}0890$. On the other hand, to make the observed and calculated values agree, the unlikely hypothesis would have to be adopted that the magnetic iron molecule is $\frac{8}{5} \times 55{\cdot}84 = 89{\cdot}9$, which would give $\Delta C = 0{\cdot}124$.

The Lorentz formula shows up clearly the systematic difference between the actual properties of the metals and those properties which are explained by the molecular-field theory. These differences cannot as yet be explained.

The authors finally set forth the modifications in the calorimeter and the methods of experimentation which it would be desirable to introduce before further work is done. L. H. W.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1101. *Rotation of the Tube for Extracting Projectiles under Radioscopic Control.* **Duvergey** and **Dufour.** (Archives d'Él. Médicale, 27. pp. 129–186, May, 1919.)—The principle of the method is to locate along two axes, the one vertical, the other oblique, the projectile in relation to the instrument employed in the search for it. To be in contact with the projectile, the surgeon must obtain for both axes a superposition of the two shadows: that of the projectile and that of the instrument. The projectile is located on the vertical axis and normal ray, and the point of the instrument is placed on the surface of the skin so that the shadow of this point coincides exactly with that of the projectile. The tube is now turned from the horizontal through a small angle, the point of the instrument not being shifted. In order that the normal ray may once again pass through the projectile, the tube must be given the same lateral angular displacement, and the shadows of projectile and instrument are now separated on the screen. By the direction in which the shadow of the instrument separates from that of the projectile, it is known whether the former is above or below the latter. The two shadows can only coincide after rotation of the bulb if the point of the instrument is in contact with the projectile. Extractions along the vertical and lateral axes are described in detail. It is also suggested that this method might be employed with advantage in the examination of fractured limbs, etc.

A. E. G.

1102. *Prolongation of Life of Tribolium Confusum by X-ray Dosage.* **W. P. Davey.** (Gen. El. Rev. 22. pp. 479–483, June, 1919.)—The author's conclusions are as follows:—(1) It has been shown that the life of *tribolium confusum* may be prolonged by the use of a purely physical agent (*i.e.*, X-rays). (2) The prolongation of life due to a series of small daily doses is greater than that produced by large doses given all at once. (3) The lethal effect of an X-ray dose is less if it is split up into a series of small daily doses, than if it is given all at once. (4) A method of graphical analysis is described by which the number of cases of death may be determined from the death-rate, and by which the effect of an external agent upon each of these causes may be studied. (5) Using the same kind of organism throughout the whole experiment, the work reported in this and the previous paper has shown that, by merely varying the size of the dose, X-rays may be made to produce at will: (*a*) a stimulation, (*b*) a destructive effect which occurs only after a lateral interval, and (*c*) an instant destructive effect. A. B. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1103. *Physico-chemical Force of Attraction.* **L. G. Gurvitsch.** (Russian Phys. Chem. Soc., J. 48. pp. 856–861, 1916.)—The phenomenon of the auto-disintegration of floridin which occurs in various liquids necessitates the assumption that the force of physico-chemical attraction which tears off small particles from the surfaces of the floridin granules is capable of similar behaviour at the surface of other substances, such as metals. Experiment shows, indeed, that metals do undergo pulverisation when shaken in the form of granules or small pieces with various liquids at the ordinary temperature. Between the degree of disintegration of the metal and the residual chemical energy of the liquid, measured by the heat of adsorption, perfect parallelism exists, and the conclusion is drawn that the pulverisation is caused by the physico-chemical force of attraction between metal and liquid. This force is alone insufficient to tear particles from the compact surface of the metal, but becomes able to do so when the impacts of the metallic fragments loosen the surface layers.

The shaking of certain liquids of specially great residual energy, such as water, methyl alcohol, acetone, etc., with metals may even lead to the formation of colloidal solutions of the metals of very considerable concentration and marked stability. The maximal percentage concentrations of the colloidal solutions obtainable on shaking 100 gm. of granulated lead with 120–130 cm.^{3} of various liquids are: water, 0·098; methyl alcohol, 0·132; ethyl alcohol, 0·0134; amyl alcohol, traces; acetone, 0·0115; pinene, 0·0088; and aniline, 0·0071. In methyl alcohol, colloidal solutions of the following percentage concentrations are obtainable: cadmium, 0·052; zinc, 0·0028; bismuth, 0·059; mercury, 0·032; and tin, 0·0031.

This procedure furnishes a very simple method for obtaining colloidal metal solutions, but it is attended with some uncertainty, which appears to be due to insufficient cleanness of the surface of the vessel in which the shaking takes place. The best results are obtained if the vessel is washed successively with chromic-sulphuric acid mixture, water, alcohol, and several times with the liquid to be employed; it should then be charged at once and closed. Excessive shaking may result in the complete deposition of the metal from the colloidal solution. T. H. P.

1104. *Matter and Light. Attempt at a System of Chemical Dynamics.* **J. Perrin.** (Annal. de Phys. 11. pp. 5–108, Jan.-Feb., 1919.)—The author attempts to show that a coherent theory can be developed according to which the cause of chemical reactions is light itself; the theory also explains and correlates certain classes of phenomena that are at first sight very dissimilar. Thus dissociation or combination, phosphorescence, radio-activity, physical changes of state—all these appear to be subject to a single fundamental law connected with the structure of the atom.

But the author admits that his study is only of a preliminary character and has only touched the subject, which is still surrounded with uncertainties and difficulties; he recognises the necessities of further experimentation, and suggests certain experiments which should be helpful, although these would be troublesome to carry out. L. H. W.

1105. *Constitution of Sulphur Vapour.* **J. J. Dobbie** and **J. J. Fox.** (Roy. Soc., Proc. 95. pp. 484–492, June 4, 1919.)—Experiments with sulphur vapour at various temperatures show a remarkable series of spectrum changes, which can only be explained by assuming changes in the molecular constitution of the vapour. The absorption increases up to about 650° C. and then diminishes, so that it is probable that molecules of some degree of complexity intermediate to S_8 and S_2, and more highly absorptive than either, are formed as intermediate products of dissociation. It appears probable, at any rate, that molecules of the composition S_3 are formed. The evidence for the existence of S_3-molecules is strengthened if we take account of the analogies between sulphur and oxygen, for ozone possesses much greater absorptive power for light than ordinary diatomic oxygen. No evidence was obtained of the resolution of diatomic into monatomic molecules at the highest temperatures used. Above 900° C. no further change could be observed in the spectrum. A. W.

1106. *The Possibility of Separating Isotopes.* **F. A. Lindemann** and **F. W. Aston.** (Phil. Mag. 37. pp. 523–534, May, 1919.)—As the existence of elements of different atomic weights which occupy the same position in the periodic system but appear to be inseparable by chemical means seems now to be generally accepted, it is of interest to consider the various methods by which there may be some hope of separating them. Theoretical considerations are now advanced to show that elements of different atomic weights must be separable in principle though possibly not in practice. Various possible methods of separating such substances are discussed.

Fractional distillation or chemical separation may be possible under suitable conditions. Diffusion must lead to a positive result, but the technique is necessarily laborious. Gravitation separation is small. Centrifugal separation appears promising, but would involve heavy outlay and elaborate preparations. Electrical separation, the only method offering hopes of a pure product, will only yield microscopic quantities even if the very serious difficulties indicated can be overcome. Experiments to separate the hypothetical constituents of neon are described, in which neither by fractional distillation nor by diffusion have conclusive results yet been obtained.
A. B. W.

1107. *Errors of Determinations of Atomic Weights.* VI. *Surface Actions as Source of Errors in Weighing.* **P. A. Guye** and **E. Moles.** (J. Chim. Phys. 15. pp. 360–404, Oct. 31, 1917.)—(1) Hinrichs' anomaly. In 1895 Hinrichs pointed out that the value of the combination-ratio was apparently a function of the quantity of substance used. The authors confirm the facts, but find that such cases are limited to series of determinations in which weighings were made in air and reduced to vacuum. The error arising from the surface condensation of air, moisture, etc., amounts on an average to 1 in 20,000 and may rise to 1 in 10,000. VII. (*Ibid.* pp. 405–432, Oct. 31, 1917.) (2) Experimental determination of the surface films adhering to solids; general conclusions. For the case of blocks of silver the minimum error amounts to 2×10^{-5} gm. per gm. of silver, with finely-powdered zinc oxide to 0·2 or $0{\cdot}4 \times 10^{-5}$ gm.; but larger errors may arise. Orders of this magnitude would affect the second decimal in atomic weights above 100. All weighing in atomic-weight determinations should be made, and can now be made, with micro-balances, in a vacuum. H. B.

1108. *Improved Method of Optical Glass Manufacture.* **G. W. Morey.** (Chem. and Met. Eng. 20. pp. 511–512, May 15, 1919.)—Paper read before the Am. Ceramic Soc., Pittsburg, Feb., 1919. Engineering, 108. p. 22, July 4, 1919.)—Instead of commencing to stir, first intermittently by hand and then by machine, after the completion of the fining period, the author starts stirring while the pot is being filled, and he thereby reduces the time during which the pot is in the furnace by one-half; he thus speaks of a "24-hour" process. It is pointed out that the batch melts from the top downward, so that the upper layer becomes rich in silica and poor in flux, which trickles down; hence partly the severe corrosion of the pot bottom and the want of homogeneity in the glass. No special method of stirring is mentioned. The 350 pots of glass made by the 24-hour process in the Spencer Lens Glass Plant, at Hamburg, N.Y., comprise various flints and crowns, baryta and borosilicate glasses, light and dense, all of which were improved by the treatment. H. B.

1109. *Identification of Stones in Glass.* **M. L. Bowen.** (Am. Ceramic Soc., J. 1. pp. 594–605, Sept., 1918.)—By stones in glass are meant foreign particles of a crystalline nature. They are distinguished as: (1) pot stones, chiefly sillimanite Al_2SiO_5; (2) batch stones, unassimilated particles of sand, appearing under the petrographic microscope as specks with long hairy tails; (3) crown drops, liquid dropping into the pot from the corroded bricks of the furnace crown; when the bricks are silica, these stones consist of tridymite rather than of cristobalite, because the latter has gradually passed into tridymite in the crown, whilst there is not as a rule sufficient time for this conversion in batch stones; with very highly-heated crowns (1470° C.), cristobalite is also observed. Finally there are (4) devitrification stones; the crystals may be large enough for direct distinction, or may be small and make the glass appear opalescent or devitrified. In any case it is not glass as a whole which crystallises, but some constituent, and the crystals are often found in spherulites; they may consist of cristobalite; CaS_2O_3 wollastonite—the author has not observed pseudo-wollastonite into which this mineral is said to pass above 1170°; $BaSi_2O_5$, and alamosite $PbSiO_3$. Since the isolation and chemical analysis of the stones is difficult, the author explains their identification by means of the microscope and their optical properties. H. B.

1110. *Attack of Glass Melting-pots by the Glass.* **W. Rosenhain.** (Engineering, 107. pp. 725–727, June 6, 1919. Chem. News, 118. p. 287, June 13, 1919. Paper read before the Soc. of Glass Technology, May 21, 1919.)—The research was conducted in the National Physical Laboratory by the author, E. A. Coad-Prior, V. Stott, and Miss A. B. Taylor. The small pots, 85 mm. in diam. filled to a height of 80 mm., are made of the purest China clay by a slip-marking process, the slip consisting of 60 % of clay and 40 % of a grog, itself obtained by baking balls of the clay above 18 cone; the axial stirrer rod, passing through the lid, is of the same clay. The glass —flints rich in barium and boric acid, and other glasses—is introduced in the shape of a water-cullet, and the pots are heated on the graphite-ring furnace of the authors. The glass attack is determined by measuring the decrease in the thickness of the rod and bottom and by microscopical examination of the glass adhering to the pot. The bottom is frequently, even when free of any defect, "drilled" in holes lying roughly in a circle, and the rods taper either to a V or to an inverted V (or A); there may also form a neck and a shoulder at the glass level. By studying the circulation and density changes with rods (salt, paraffin, etc.) in various solvents (water, carbon tetrachloride), the authors find that a V taper is formed when the resulting solution is lighter than the solvent, and an A taper when heavier. In the pot the erosion can be prevented to a certain extent by deflecting the convection currents and by changing the composition of the glass; the pot attack is more serious at 1280° than at 1260°. The agitation of the surface layer is very strong when necks are formed. The pots are also examined by X-rays before and after firing. Iron specks appearing all dark before firing turn into dark rings with a grey centre by firing, and air-bubbles can easily be distinguished. **H. B.**

1111. *The Welding of Glasses.* **L. Appert.** (Soc. d'Encouragement, Bull. 131. pp. 67–91, Jan.–Feb., 1919. Nature, 103. p. 271, June 5, 1919.)—The author discusses the welding of glasses and enamels with one another and with metals, with reference to athermancy and diathermancy, inalterability and neutrality, first on historical lines. There is no mention of special experiments, nor are there any literature references. He concludes that all glasses of different compositions can be completely and permanently welded and that the limits within which the relative proportions may be varied are very narrow; with regard to thermancy a standard of known composition should be used; neutrality should be tested with the blowpipe. In the case of enamels the mordant should have the same dilatation coefficient from the outset and the enamel be applied in successive very thin layers. **H. B.**

1112. *Glass Analysis. Determination of the Two Arsenic Oxides and of Boric Acid. Condition and Rôle of Arsenic in Glass-making.* **E. T. Allen** and **E. G. Zies.** (Am. Ceramic Soc., J. 1. pp. 1–48, Nov., 1918.)—The paper describes the methods adopted for the analysis of 9 Jena optical glasses and of some American glasses with special reference to the separate determination of the trivalent and the pentavalent arsenic. When the glass is treated with hydrofluoric and sulphuric acids, the arsenious acid is volatilised as AF_3, whilst the arsenic acid remains in the residue and is subsequently precipitated as sulphide; the latter is oxidised to arsenic acid, reduced by hydriodic acid and determined by titration. The total arsenic is found by fusing the glass with sodium carbonate and nitre, and treating the arsenic acid as stated; the method is more accurate and expeditious than the magnesium polyarsenate method. As regards boric acid, Chapin's method is recommended; the presence of arsenious (not of arsenic) acid and of fluorides in relatively large quantities causes difficulties. Moisture is always present in glass samples; gases were not determined. The Jena glasses had evidently been made from very pure materials and in very refractory pots.

In all the glasses tested, both plate and optical glass, the arsenic seems chiefly to be present in the pentavalent state, but a portion exists in the trivalent state. Arsenic is used in order to whiten the glass and to fine it, the latter because it causes the glass to boil. The experiments made by the authors show that some As is lost and volatilised during the manufacture of the glass, as trioxide; the arsenious acid is probably first oxidised and then dissociated again into oxygen and trioxide; but the problem is not settled. **H. B.**

1113. *The Mechanism of the Quenching of Carbon Steels.* **P. Chevenard.** (Rev. de Mét. 16. pp. 17–19, Jan.–Feb., 1919.)—This paper is a more complete and detailed account of the author's work described in Abs. 1192 (1917.)—Study of the quenching of wires and determination of the intensity of the cementite anomaly in treated steels show that martensite is an unstable solid solution of carbon in iron, while troostite, osmondite, and sorbite are aggregates of iron and cementite. F. C. A. H. L.

1114. *Changes in Metals brought about by Cold-working and Alloying.* **P. Ludwik.** (Zeits. Vereines Deutsch. Ing. 63. pp. 142–144, Feb. 15, 1919.)—X-ray examination has vastly increased our knowledge of the structure of crystals and the space-lattice is no longer a hypothetical conception. Cold work brings about distortion of the space-lattice which is effected by movement along the gliding planes. Strengthening is due to a blockade of the gliding planes which steadily increases with the magnitude of the deformation until ultimately the crystal becomes homotropic. Reversal of movement along the gliding planes accounts for the detrimental effect of alternating stresses. Variation of the annealing temperature with the degree of deformation is also considered. The conception of molecular homology indicates a close relation between the absolute fusion temperature and the absolute temperature at which the effects of deformation are removed; it also renders possible an explanation of the influence of the velocity of deformation on hardness and strength, and the deduction of simple relationships between thermal expansion, heat capacity, heat of fusion, and modulus of elasticity. Very little work has been done in the direction of determining the reason for the enormous effect on the properties of a metal caused by the introduction of traces of other materials. It is possible that the introduction of atoms of a foreign element does cause a slight distortion of the space-lattice but of a different nature from that produced by cold work. In solid solutions and isomorphous mixtures the hardness will depend upon the number of atoms in solution and the degree of distortion produced, but in mechanical mixtures the hardness in the stable state (often only attained after very prolonged annealing) will be determined by the application of the law of mixtures. The rate of cooling and degree of dispersion will, however, produce many intermediate states and in view of the enormous structural variations in alloys simple general relationships between constitution and mechanical properties will be difficult to find. F. C. A. H. L.

1115. *Flaky Fractures and their possible Elimination.* **H. Styri.** (Chem. and Met. Eng. 20. pp. 478–483, May 1, 1919.)—The author summarises the work done on non-metallic inclusions in steel, and discusses the equilibria of iron oxides and carburised iron. From these the following deductions are drawn:—The deoxidising power of manganese is greatly increased by the presence of silicon since the MnO formed will then combine with SiO_2 formed at the same time, thus reducing the content of both in the slag. It is considered that the "boil" in steel-making processes is produced as a result of an increased temperature changing the physico-chemical conditions, so that oxides of Si and Mn previously formed at lower temperatures are no longer produced at more elevated temperatures, the carbon being preferentially removed. It is considered that the freezing of an ingot should be of the "onion" type of Howe, since a greater proportion of inclusions thus have an opportunity of rising to the surface. It is further suggested that the ingot moulds should be heated and the ingots stripped as soon as possible after casting, before any part has fallen in temperature below the $Ar1$ point, then transferring them to a soaking pit. F. C. T.

1116. *Hardness and Resilience of Gold-Copper Alloys.* **A. Portevin** and **J. Durand.** (Rev. de Mét. 16. pp. 149–151, March–April, 1919.)—A brief account of the preliminary results of a research, interrupted by the war and not resumed because Kurnakov had meanwhile continued his study of these alloys. Gold with 20 or 30 % Cu, commercially called red gold, is known to be brittle. Experimenting with alloys the copper percentage of which increased by steps of 10 %, the authors find the greatest Brinell hardness and the smallest strength (resilience, Guillery machine) in specimens containing 20 % Cu; with higher Cu percentage the hardness decreased and the strength increased again. The weakest alloy has a needle-fracture, that of the 30 % Cu alloy is of the acanthus-leaf type. H. B.

1117. *Quenching Cracks in Carbon Steels.* **K. Honda** and **T. Matsushita.** (Tohoku Univ., Sci. Reports, 8. pp. 31–42, April, 1919. Twenty-fifth Report of the Alloys Research Inst.)—The cracking of high-carbon steel on quenching is shown to occur only when the temperature of quenching exceeds A*c*1 on heating or A*r*1 on cooling. The authors conclude that the cause of the rupture is neither the stress set up as a result of temperature difference between adjacent parts due to unequal cooling, nor the sudden stresses involved during the passage of the specimen through the A1 transformation, but to persistent stresses due to the differential expansion of adjacent parts caused by different degrees of martensitisation. It is shown that although in a certain quenching the greatest difference of temperature between the centre and the outside (300 deg. C.) occurred 8·5 secs. after immersion, the crack was formed 10 secs. after the quenching when the centre and periphery differed in temperature by less than 100 deg. C. Parts of quenched specimens subject to compressional stresses only are not subject to cracks, which are formed solely where tensional stress is involved. A short cylinder quenched vertically showed no cracks in the lower half although cracks extended over the whole length of the upper half. These cracks were both radial and concentric. The explanation of the cracking at the low temperature is as follows: At the surface where cooling is most rapid and the structure most completely martensitic a continuous contraction occurs down to a temperature of about 200° C., after which expansion sets in which becomes more and more pronounced down to room temperature. At the centre a certain decomposition of the martensite occurs, with the result that expansion occurs at the temperature of A*r*1, after which uninterrupted contraction occurs. The two curves cut at a point somewhat below 200° C. and as the temperature falls, rapidly move apart, with the result that increasing stresses are set up which ultimately at relatively a very low temperature lead to rupture. F. C. T.

1118. *Sintering of Magnesia.* **J. B. Ferguson.** (Am. Ceramic Soc., J. 1. pp. 439–440, June, 1918.)—In determining the melting-point of cristobalite and tridymite a special electric furnace (not described) was used, and the magnesia packed between the inner and outer heater and replenished during the heating, between 1600° and 1720°, was after several hours found to have turned into a dense cake of considerable mechanical strength. The product was essentially periclase (MgO) in interwoven crystals, without any binding material; only a little forsterite ($2MgO.SiO_2$), less than 0·5 %, was present. H. B.

1119. *Temperatures attained during Explosive Reactions.* **H. Muraour.** (Comptes Rendus, 168. pp. 995–997, May 19, 1919.)—When explosion-temperatures are indirectly determined, either from the heat evolved and the specific heats of the products, or from the pressure and volume of the gas in the bomb, it is doubtful whether the methane found was formed during the explosion or during the subsequent cooling, and the temperature estimates may hence be uncertain by 400 deg. C. Koehler and Poppenberg had attempted to determine the amount of CH_4 at the moment of the explosion and had found this amount to be very small. It has become customary, however, to allow for the direct formation of CH_4 in artillery calculations.

The author describes experiments in which the explosion gases were rapidly cooled by escaping from an "erosion-bomb" (of the Laboratoire Central du Poudre) into a large bomb of 4 litres' capacity, previously evacuated, and partly charged with silver or mercury to hasten the cooling, the connecting canal being a bore (in steel or silver) of 1 mm. diameter. Experiments with various powders yielding much CH_4 prove that most of the CH_4 found—if not all—must be formed during the cooling period; the combustion gas should hence be calculated as $CO + H_2$, contrary to the usual assumption, and the density of the charge would not influence the explosion-temperature. The analytical method is not explained. H. B.

1120. *Mixed Crystals.* **C. Viola.** (Accad. Lincei, Atti, 26. i. pp. 195–207, 1917.)—The author proceeds to examine the equilibrium contact conditions between a mixed crystal and the amorphous phase from which it originates. This problem is solvable by means of the data required to prove Curie's law, according to which the growths perpendicular to the faces of a crystal are directly proportional to their respective capillary constants.

The mixed crystal is composed of two constituents, that is, of two crystals in intimate contact in their smallest parts. It will be in equilibrium with the amorphous phase, which contains the same constituents, but usually in different proportions, when (1) the proportion between the two components does not alter, although the total mass changes in correspondence with Gibbs's phase rule, (2) the surface energy is a minimum in correspondence with the least action, and (3) the total volume of the mixed crystal does not vary, the only possible variation being in the form.

It is shown analytically that the mean growths perpendicular to the faces of the mixed crystal are directly proportional to the mean capillary constants of the two components. From this it follows that the normal figure of a mixed crystal is the mean of the normal figures of the crystals composing it in the proportions in which these are found in the mixed crystal. It is shown further that the total surface energy is always directly proportional to the total volume of the mixed crystal, this being Curie's law, and that the difference in the surface energies of the components is directly proportional to the difference in the volumes at every instant of the growth, no matter what the relation between the components of the mixed crystal. Isomorphous crystals are defined as those having the same structure and the same surface density, and therefore exhibiting continuous miscibility between limits which include the mean miscibility. Various examples are considered in order to illustrate the significance of the inclusion in the above definition, of the idea of mean miscibility. T. H. P.

1121. *General Method for obtaining Metals in a Metalloidal Condition.* **P. P. v. Weimarn.** (Russian Phys.-Chem. Soc., J. 48. pp. 1295–1314, 1916.)—Investigation of the colour of disperse systems with metallic disperse phases and of the colour of the disperse molecules with the aid of the ultramicroscope shows that, as regards their colour, such systems form two groups. The first contains relatively coarsely-disperse systems, and the disperse particles in them still retain metallic reflection and dispersion; the second, the comparatively highly disperse systems with disperse particles exhibiting the optical properties of non-metallic substances, that is, of substances with so-called internal colour. In the first group the colour changes with the degree of disperseness exactly as in coarsely disperse systems of metalloidal selenium, and in the second group as with a transparent, coloured substance which absorbs the red and blue parts of the spectrum and transmits orange, yellow, and green light. These two groups of disperse systems of one and the same element contain the latter in two different states, namely, the metallic and the metalloid, the optical properties being different in the two cases. No sharp line separates these two states, intermediate stages being quite possible. Such measurements as those of Galli ("Das optische Verhalten dünner Metallschichten," Dissertation, Göttingen, 1913) on the index of refraction of thin layers of silver deposited on glass by kathodic disintegration show that at a sufficiently high degree of dispersion even typical metals pass from the metallic to the metalloidal condition. The value of the refractive index of the transparent, intensely coloured metalloidal substance then obeys the same rule as for all metalloids.

Of the three known modifications of selenium, the author has investigated two: (1) the red, crystalline metalloidal form which melts at 170–180° when rapidly heated and at 150° is converted into the metallic modification melting at 217°. The latter form is not transformed on cooling into the red variety, which is obtainable only by quickly cooling the fused metallic Se from a temperature of 250°. Thus, in the coarsely disperse condition, on rise of temperature, red metalloidal Se $\longrightarrow$ grey metallic Se. If, however, the condition is sufficiently highly disperse, the reverse change may be induced. Further, Saunders found that grey metallic Se, when finely powdered, is converted into the red metalloidal form, which at about 200° is transformed into the grey variety, and so on. T. H. P.

1122. *Velocity of Solution of Zinc in Acids.* **M. Centnerszwer.** (Russian Phys.-Chem. Soc., J. 48. pp. 470–524, 1916.)—A number of further results have been obtained [see Abs. 502 (1916)], the principal ones being as follows.

Etched zinc dissolves in hydrochloric acid more rapidly than zinc with a polished surface. The metal, which reaches its max. velocity of dissolution in 2N-hydrochloric acid, dissolves in fresh acid with a continually diminishing velocity, and the process of solution follows Boguski's law. Sulphuric acid dissolves zinc appreciably more slowly than does hydrochloric acid with an equal concentration of hydrogen ions. Zinc sheets from one and the same melt dissolve with different velocities, owing to variations in the crystalline structure of the metal, but with rolled zinc sheets, concordant results are obtained. Zinc which has been treated with emery dissolves more rapidly than polished zinc, and zinc plates subjected to the action of iodine solution more rapidly than fresh plates. The velocity of dissolution of the metal increases more rapidly than the concentration of the acid, and the black precipitate which forms at the surface of the metal during the action accelerates dissolution, removal of this precipitate resulting in the loss of the former activity of the metal. In distilled water, zinc retains its activity for a long time, but in the air the metal partly loses its activity. When rapidly cooled, zinc exhibits a more pronounced induction period than when slowly cooled, but if its surface is subsequently etched, its velocity of dissolution is the same as in the latter case. Prolonged heating at 400° of zinc which has been rapidly cooled increases its period of induction. The potential of active zinc is somewhat higher than that of passive zinc.

In order to explain the phenomena observed, the supposition is made that ordinary (chemically pure) zinc is in a passive condition, increase of the velocity of dissolution during the period of induction being explained by transformation of the metal from the passive to the active state. T. H. P.

1123. *An Electromagnetic Hypothesis of the Kinetics of Heterogeneous Equilibrium, the Structure of Liquids, and Cohesion.* **W. D. Harkins and H. H. King.** (Am. Chem. Soc., J. 41. pp. 970–992, June, 1919.)—In this paper the hypothesis is developed that the distribution of a solute between various regions (phases and interfaces) is conditioned by the intermolecular electromagnetic fields. Cohesion is considered to be due to these fields, and is explained on the basis of the valence theory of G. F. Lewis as being due to intermolecular fitting of electrons in the outer shells of the atoms. The constant surface film of butyric acid on the surface of water is found to contain $2{\cdot}78 \times 10^{14}$ molecules, while if benzene covers the water phase, the layer contains $2{\cdot}79 \times 10^{14}$ molecules per cm.². Thus the presence of the benzene does not affect the number of molecules in the film. A theory of solubility and of thermodynamic environment is developed, and a hypothesis is presented to explain the variation of the activity, fugacity, or thermodynamic potential of a component, with variations in its environment. Various topics, such as Raoult's law, solubility, melting-points, compressibility, coefficient of expansion, latent heat of vaporisation, adsorption, and surface structure, are discussed. The theory presented is too complicated for presentation in a summary, and should be looked for in the body of the paper. AUTHOR.

1124. *Relation between Mechanical and Chemical Distortion of Liquid Crystals.* **O. Lehmann.** (Ann. d. Physik, 58. 7. pp. 631–656, May 9, 1919.)

1125. *Concentrated Solutions.* II. *General Boiling-point Law.* **E. W. Washburn and J. W. Read.** (Am. Chem. Soc., J. 41. pp. 729–741, May, 1919.)—Apparatus and method for measuring the boiling-point elevation of solutions, based upon the determination of the composition of the liquid phase which at a definite temperature and pressure is in equilibrium with the vapour phase, and for demonstrating the validity of the boiling-point law for ideal solutions at high concentrations. As in Abs. 627 (1916) the solvent selected is benzene and the solutes giving "ideal" solutions are diphenyl and naphthalene. The apparatus is a modification of an apparatus of F. G. Cottrell, by means of which perfect equilibrium between the two phases can be secured and the temperature of this equilibrium be exactly determined, when both the phases are under exactly the same pressure. Numerical data are given, and special attention is drawn to the influence of the barometric pressure on the boiling-point elevation and to the determination of molecular weights. For the latter determination solvent and solute should closely resemble one another chemically, and the boiling-point of the solvent should be relatively high. H. B.

1126. *Eutectic Mixtures and Dilute Solutions.* **A. Colson.** (Comptes Rendus, 168. pp. 942–944. May 12, 1919.)—The formation of a eutectic mixture has already been expressed by the solubility formula, $425 \times L = T (V + \iota)\, i \,.\, dC/dT$. The volume V of the solvent which includes 1 mol.

of saturated solution (the volume which is inversely proportional to the solubility by volume) increases for $L < 0$ under the influence of cooling and passes through a minimum when L changes sign. The author now shows that V generally attains a maximum at which it remains invariable during the work of cooling. It is this maximum which corresponds to the eutectic phenomenon. The changes which a saturated solution of sodium chloride undergoes are then described in illustration of the above result. The eutectic is given by the angular point arising from the intersection of the saturation curve with the solidification curve of dilute solutions. If C′ stand for the solvent concentration in the solution, L′ for the heat of solution of a molecule of the solidified solvent in the volume corresponding to C′ at a temperature T higher than the eutectic temperature T_e, then 425 $L' = T(V' + \varepsilon')i' . dc'/dT$, and since $C' = 100 - C$, therefore $dC'/dT = -dC/dT$. The substitution of the value of the salt concentration C for C′ in the last equation thereby gives a relation between the salt concentration and temperature T of fusion of the solvent in a solution where the salt concentration is C. The value L′ remains positive, and dC/dT should therefore be negative, *i.e.*, the temperature T increases when the concentration C diminishes, which is in conformity with the facts. The curve represented by the first equation is the curve of saturation of salt in solvent, or, more generally, of a body A in a body B. The curve represented by the second equation relates to the saturation of B in A. The meeting-point gives the mutual saturation of the two bodies and denotes a eutectic, since cooling brings about the simultaneous solidification of both bodies A and B. The above equations are of general application, *e.g.*, to the mutual solution of organic bodies and to alloys. The second equation, which has been derived from the rational law of saturated solutions, should express all the properties of dilute solutions and in particular should lead to the cryoscopic properties experimentally established by Raoult. H. H. Ho.

1127. *Dissociation of Electrolytes as a Function of the Neutral Molecule.* **B. de Szyszkowski.** (Nobel Inst., Meddel. 3. No. 2 [48 pp. in English], 1915.)—The author summarises his conclusions as follows :—

(1) A general dissociation function of electrolytes, applicable to all salts and acids up to a concentration of 0·5 has been established, namely, $D = K + k(c_0^1)^m$, or in a different transcription $\Phi\ K + ac_0^1$. (2) Sufficient evidence has been given in favour of Walker's hypothesis that the deviations of strong electrolytes from the dilution law are due to neutral molecules and not to ions. (3) The power of the neutral molecule to increase the dissociation has been measured for all investigated electrolytes and expressed by means of the activity coefficient of the neutral molecule *a*, which varies between 6 and 0, the smallest value determined being 0·00025. (4) The existence of a proper dissociation-constant of strong electrolytes K, first shown by Arrhenius, has been definitely proved, its order of magnitude for salts being 0·01. (5) A comprehensive classification of electrolytes has been given, based upon the values of *a*. L. H. W.

1128. *Actual State of the Theory of Electrolytic Dissociation.* **B. de Szyszkowski.** (Nobel Inst., Meddel. 3. No. 11 [16. pp., in English], 1916.) The author points out that neither the conclusions of Kraus and Bray nor those of Sachanov are valid over the full extent of the dissociation curve. A mathematical expression which would sum up all the properties and peculiar points of the curve and also take into consideration Krauss s

$me =$ const., should take the form $C\alpha^2/(1-\alpha) = k_m(c_0^{\frac{1}{3}})^{\alpha e} + k_n(c_0^{\frac{1}{3}})^n + K$. This formula, however, cannot account for the occurrence of a maximum of molecular conductivity at very high concentrations in solvents of small inductive capacity such maximum must be due to the increase in viscosity of the solution, and obviously, cannot be expressed by a dissociation function. L. H. W.

1129. *Electrolytic Dissociation of Individual Salts.* **A. N. Sachanov.** (Russian Phys.-Chem. Soc., J. 48. pp. 341–361, 1916.—The author's previous work on the electrical conductivity of silver nitrate in solution in different solvents indicates that, even in absence of solvent, this salt exhibits electrolytic dissociation, and in the present paper the consequences of this result, and its bearing on the conclusions drawn by various investigators, are discussed. T. H. P.

1130. *Movement of the Ions during Electrolysis.* **C. Del Lungo.** (N. Cimento, 16. pp. 173–181, Sept.–Oct., 1918.)—By application of Stokes' law to the question of the movement of the ions, the author deduces theoretically Walden's empirical law, according to which, for one and the same electrolyte, the product of the viscosity of the solvent and of the equivalent conductivity, Λ_0, is a constant magnitude, independent of the temperature. It is found also that the variation of the conductivity, Λ_0, should depend solely on the variation of the viscosity-coefficient, η, as it may be assumed that, at least within certain limits, change of temperature does not sensibly influence the diameters of the ions. Consequently, the temperature variation of Λ_0 should be virtually the same for all electrolytes in aqueous solution. Not only is the law in general verified for salts, but the temperature-coefficients of conductivity between 18° and 40° have the limiting values $2{\cdot}3 \times 10^{-12}$ and $2{\cdot}6 \times 10^{-12}$, which correspond closely with the temperature-coefficient of the viscosity of water.

Stokes' law allows also of calculation of the diameter of the ions, and the values thus derived are in good agreement with those deduced in accordance with the kinetic theory of gases. In general, the ions are small in comparison with the molecules, but the difference is exceptionally marked with the ions $H^{\cdot}$ and OH', the diameters of which are only about one-half of what they should be according to the diams. of the molecules H_2, O_2, and H_2O. The existence of free $H^{\cdot}$ and OH' ions in all aqueous solutions, and perhaps in greater number in solutions of acids and bases, would cause the calculated velocities of the ions of the electrolyte to be greater than the true values; these considerations would explain the exceptionally high values obtained for the transport velocities of the ions $H^{\cdot}$ and OH' and the low values of the corresponding temperature-coefficients, and of the diameters calculated according to Stokes' law. It appears that the ions $H^{\cdot}$ and OH' exist under special conditions different from those shown by other ions, and that the friction between them and water molecules is far less than with other ions.

The dimensions of the ions of the metals and of the non-gaseous non-metals given by Stokes' law are compared with those calculated on the basis of the atomic volumes. The agreement is good for univalent elements, with the exception of potassium, but there is a moderately high and approximately constant difference in the case of the divalent metals. T. H. P.